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# Memoirs of the Department of Agriculture in India

## STUDIES IN GUJARAT COTTONS, PART II

BY

**MAGANLAL L. PATEL, B. Ag**
*Cotton Breeder, South Gujarat*

**AGRICULTURAL RESEARCH INSTITUTE, PUSA**

PRINTED AND PUBLISHED FOR
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BY
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# STUDIES IN GUJARAT COTTONS, PART II.

BY

MAGANLAL L. PATEL, B.Ag.,

*Cotton Breeder, South Gujarat.*

[Received for publication on the 9th July, 1923.]

In the author's former Memoir on Gujarat cottons[1] he described the various types of cotton which are grown in that part of Western India, and gave a detailed description of the variety known as *goghari* which forms one of the three main types of *Gossypium herbaceum* cultivated in Gujarat, which is characterised in all its strains by roughness, shortness of staple, and high ginning percentage. The present Memoir deals essentially with the second of the great varieties of *Gossypium herbaceum* of Gujarat, namely, that known as *broach deshi*, or *lalio*, together with a critical consideration of the environment, chiefly climatic, of the cotton plant in Gujarat, and also with a number of other observations on the general botanical characteristics of *Gossypium herbaceum* cottons.

## I. THE ENVIRONMENT OF COTTON IN SOUTH GUJARAT.

Gujarat consists essentially of a flat plain lying almost at sea level, and stretching between the sea and various mountain ranges, from a hundred miles north of Bombay, northward to the fringe of the Rajputana desert. In the present description the conditions are considered which prevail in South Gujarat, of which Surat may be taken as the most typical centre, and which differ in a very marked manner both in climate and soil from the regions north of Baroda.

The general aspect of this South Gujarat region, and especially of the portion—from within five miles of the sea to twenty miles inland—where cotton is chiefly grown, is that of a flat plain formed by the alluvium deposited in the basins of the Tapti and the Nerbudda rivers. The soil, being derived from the region of the Deccan trap, has all the characteristics of the black cotton soil or

[1] Studies in Gujarat Cottons, Part I, *Mem. Dept. of Agri. India, Bot. Ser.*, Vol. XI. No. 4, 1921.

*regur* of Western India, varying in depth and in stiffness, however, considerably from place to place.

This black soil possesses in this region in a pre-eminent degree the power of expansion and contraction on wetting and drying respectively, which is the most obvious character of black cotton soil. As a result, in the hot weather, it is traversed by deep and wide cracks which disappear with the first advent of the rains. The cracking of the soil is considered by the people to be a great advantage, as it leads to the surface soil being mixed with the subsoil either during the process of cultivation or during the first rains. The flow of the water into the cracks carrying with it a large amount of surface soil leads on the one hand to a capacity on the part of the soil to absorb a very large amount of rain—even up to seven or eight inches—in one continuous fall, without surface wash or erosion, and to the conversion of a field into a series of basins, specially if the previous crop be a deep-rooted one, which needs to be levelled up before any further operation is undertaken. Though the soil at the first monsoon rain is capable of absorbing an enormous amount of water, once the cracks are filled up and the soil saturated, the water drains away so slowly, that it can only absorb further water with difficulty, and if the rain remains continuous and heavy, erosion takes place, water stagnates on the surface and all the signs of temporary water-logging are seen.

The following analysis of typical cotton growing soils from two centres in the tract in question will indicate some of the characteristics which are found. The surface soil is from the surface to eight inches deep; the subsoil represents the next eight inch layer.

| | Surat | | Navsari | |
|---|---|---|---|---|
| | Surface soil | Subsoil | Surface soil | Subsoil |
| Mechanical analysis | Per cent. | Per cent. | Per cent. | Per cent. |
| Sand (particles over 0·032 mm. diameter) .. | 26·0 | 23·3 | 32·9 | 34·2 |
| Fine sand (particles 0·016 to 0·032 mm.) .. | 33·0 | 31·0 | 23·8 | 24·9 |
| Coarse silt (particles 0·006 to 0·016 mm.) .. | 17·3 | 20·0 | 18·9 | 18·2 |
| Medium silt (particles 0·004 to 0·006 mm.) .. | 12·6 | 13·9 | 12·6 | 11·8 |
| Fine silt (particles 0·002 to 0·004 mm.) .. | 6·6 | 6·3 | 7·4 | 6·0 |
| Clay (particles under 0·002 mm.) .. | 3·6 | 4·6 | 4·4 | 4·9 |
| Chemical analysis | | | | |
| Organic matter and combined water .. | 6·0600 | 5·4600 | 6·0900 | 5·8100 |
| Lime (CaO) .. .. .. | 2·5700 | 2·5300 | 1·4400 | 1·6800 |
| Combined carbon dioxide .. .. | 0·1700 | 0·1600 | 0·0500 | 0·0500 |
| Available potash ($K_2O$) .. .. | 0·0074 | 0·0031 | 0·0071 | 0·0070 |
| Available phosphoric acid ($P_2O_5$) .. .. | 0·0070 | 0·0030 | 0·0066 | 0·0044 |

The mechanical analysis hardly illustrates the real character of these soils. It, however, shows them as essentially coarse grained soil, their clayey and plastic character being due to a large proportion of actual colloid material which an ordinary mechanical analysis is not able to show. From the chemical point of view the soil contains much lime extractable by hydrochloric acid, but very little of it in the form of carbonate. The available potash and phosphoric acid, as determined by Dyer's method, is about normal for this class of soils in the tropics.

The soils which have been described are typical of the real centre of the cultivation of *broach deshi* cotton in South Gujarat, and the centres in which this cultivation is most highly developed, are actually in the Surat District. North of this, even in the Broach District itself, the purity of the cotton grown rapidly declines and the production is chiefly a mixture of *broach deshi* and *goghari* cotton. In this area the soil also changes in character, becomes much lighter in agricultural character, and ultimately, as one goes further north, is replaced by a typical alluvial silt to the north of Baroda.

But if the typical *broach deshi* cotton area in Southern Gujarat has a characteristic soil, it may be at once said that the climate is likewise quite characteristic, the total rain being greater than in most of the Indian cotton areas, though that rain is entirely concentrated in the months from June to October. From the end of this last month (October) to the following June, no rain usually falls. The average figures for Surat and for Jalalpur (in the Navsari cotton tract) for 44 years are as follows :—

| Month | Surat | Jalalpur (Navsari) |
|---|---|---|
| | Inches | Inches |
| January .. .. | .... | .... |
| February .. .. | .... | .... |
| March .. .. | .... | .... |
| April .. .. .. | .... | .... |
| May .. .. .. | .... | .... |
| June .. .. .. | 8·48 | 9·33 |
| July .. .. .. | 16·69 | 21·27 |
| August .. .. | 7·76 | 9·45 |
| September .. .. | 6·14 | 8·07 |
| October .. .. | 1·65 | 1·86 |
| November .. .. | .... | .... |
| December .. .. | .... | .... |
| | 40·72 | 49·98 |

Thus the average total rainfall in the tract is between 40 and 50 inches, but it is very variable, far more so than is usual in the American cotton

areas, producing cotton of similar staple. In Texas, for example,[1] the average rainfall in the growing months is as follows :—

| Month | Rainfall in inches |
|---|---|
| April .. .. .. .. .. | 3·0 |
| May .. .. .. .. .. | 3·7 |
| June .. .. .. .. .. | 3·1 |
| July .. .. .. .. .. | 3·0 |
| August .. .. .. .. | 2·1 |
| September .. .. .. .. | 2·9 |

The co-efficient of variability for the Texas rainfall is in April 52·0, in May 37·0, in June 50·0, and in July 46·8, or an average for these four most important months of 46·4. At Surat, on the other hand, the co-efficient of variability of the rainfall works out at 76·7 in June, 50·9 in July, 68·9 in August and 91·3 in September. This gives an average of 71·9, and shows how much more variable is the total rainfall in the Surat-Navsari area than it is in Texas.

This variability is illustrated by the following table showing the frequency with which certain ranges of total annual rainfall have occurred in the last 45 (Surat) or 44 (Jalalpur-Navsari) years respectively.

| Range of total rainfall | Number of occurrences | |
|---|---|---|
| | Surat | Jalalpur-Navsari |
| Under 16 inches .. .. | 2 | 1 |
| 16 to 24 „ .. .. | 5 | 2 |
| 24 to 32 „ .. .. | 5 | 4 |
| 32 to 40 „ .. .. | 11 | 7 |
| 40 to 48 „ .. .. | 8 | 7 |
| 48 to 56 „ .. .. | 7 | 5 |
| 56 to 64 „ .. .. | 5 | 7 |
| 64 to 72 „ .. .. | 1 | 6 |
| 72 to 80 „ .. .. | 0 | 3 |
| Over 80 „ .. .. | 1 | 2 |
| Total .. | 45 | 44 |

At Surat the most frequent rainfall is between 32 and 40 inches, with a greater likelihood of it being over 40 inches than under 32 ; at Jalalpur-Navsari there is almost equal probability of the rainfall being anywhere between 32 and 64 inches.

[1] Kincer, J. B. Correlation of weather conditions and production of cotton in Texas, *Monthly Weather Review*, Vol. **43**, p. 64 (February 1915).

Treating the rainfall for each of the rainy months (June to September), the frequency of various amounts of rain is shown in the following table :—

| Range of monthly rainfall | Number of Occurrences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Surat | | | | Jalalpur-Navsari | | | |
| | June | July | August | September | June | July | August | September |
| Under 4 inches .. | 15 | 3 | 13 | 22 | 11 | 1 | 8 | 13 |
| 4 to 8 „ .. | 10 | 3 | 16 | 11 | 11 | 5 | 13 | 17 |
| 8 to 12 „ .. | 8 | 6 | 7 | 5 | 10 | 4 | 11 | 3 |
| 12 to 16 „ .. | 6 | 12 | 3 | 5 | 3 | 5 | 4 | 6 |
| 16 to 20 „ .. | 2 | 8 | 5 | 1 | 6 | 8 | 4 | 5 |
| 20 to 24 „ .. | 4 | 4 | 1 | 0 | 1 | 5 | 4 | 0 |
| Over 24 „ .. | 0 | 9 | 0 | 1 | 2 | 16 | 0 | 0 |

The most frequent rainfall in Surat is, therefore, below 2 inches in June, between 12 and 16 inches in July, between 4 and 8 inches in August and below 2 inches in September.

At Jalalpur-Navsari, on the other hand, a rainfall of anything below 12 inches in June is almost equally probable, while the most frequent amount of rain in July is over 24 inches. In August and also in September the commonest rainfall lies between 4 and 8 inches.

With the present information in hand it is difficult to establish a close correlation between the total rainfall and the average yield of the cotton crop in this region. The table at the end of the present chapter indicates the total rainfall and the average yield of seed cotton in cotton-*jowar* (*sorghum*) rotation on the Surat farm in every year since 1897. From this it will be seen that the 2 years of the highest yield, when crops of 643 lb. (1912) and 631 lb. (1920) of seed cotton were obtained, had a rainfall of 51·68 inches and 25·02 inches respectively. Similarly the lowest yield is given in 1900 (87 lb. of seed cotton) and 1911 (91 lb. of seed cotton) with a rainfall of 34·19 inches and 17·30 inches respectively. On the other hand, more than an average crop was obtained with a rainfall of 17·65 inches in 1918-19. It is, in fact, obvious that any connection between the total rainfall and the yield is very indirect, and that a much closer analysis is required if any correlation between rainfall and yield is to be established similar to that which has been made out to exist in Texas.

TEMPERATURE IN THE SURAT COTTON AREA.

The following table shows for each month at Surat (1) the average maximum shade temperature, (2) the average minimum shade temperature, and (3) the absolute maximum temperature.

| Month | Average maximum shade temperature of 38 years | Average minimum shade temperature of 38 years | Absolute maximum shade temperature (average of 15 years) |
|---|---|---|---|
| | °F | °F | °F |
| January .. .. | 86·6 | 57·7 | 96·3 |
| February .. .. | 88·3 | 59·4 | 100·4 |
| March .. .. | 95·7 | 66·5 | 108·1 |
| April .. .. | 99·3 | 73·4 | 110·4 |
| May .. .. | 96·9 | 78·7 | 109·9 |
| June .. .. | 93·0 | 79·5 | 102·5 |
| July .. .. | 87·4 | 78·1 | 96·3 |
| August .. .. | 86·7 | 76·9 | 92·4 |
| September .. | 88·7 | 75·7 | 98·4 |
| October . .. | 94·0 | 71·9 | 103·6 |
| November.. .. | 91·8 | 64·5 | 100·6 |
| December .. | 87·8 | 59·0 | 96·2 |

The cotton is sown normally in June and the crop is reaped from February to April. The period of most rapid development of the plants is in October, after the rains are practically over, and when all chance of water-logging of the soil has ceased. October is, however, a very hot month, for though the minimum temperature is falling at that time of the year, the maximum reaches the highest point in the year, except for the hot weather from March to May. After October the rate of growth diminishes. The high temperature in March and onward causes very rapid and often premature opening of the later formed bolls. No frost is to be feared in this tract, the lowest temperature on our records being 42°F. in February 1911 and 47°F. in January 1906. Neither of these temperatures affected the cotton in any way.

The mean temperature during the growing period is considerably higher than that in other countries producing cotton of equal or better staple than that obtained from South Gujarat. The following figures may be interesting in this connection.

| | Mean temperature | |
|---|---|---|
| | April to August | September to November |
| | °F | °F |
| *America* | | |
| Mississippi .. .. | 76 | 66 |
| Texas .. .. | 76 | 71 |
| Georgia .. .. | 69 | 62 |
| *Egypt* | | |
| Cairo .. .. | 76 | 71 |
| *Surat* .. .. | 85 | 81 |

## Humidity.

Seeing that the Navsari area produces the best quality of *broach deshi* cotton and this is probably the best staple cotton in India, the effect of the humidity of the atmosphere on the quality of this cotton cannot be left out of consideration. The Navsari tract is, in fact, the most humid in the India cotton areas, and the local belief is that this humidity has a good deal to do with the quality of the cotton produced. This is in accord with experience elsewhere. Orton[1] claims that humidity is a prominent factor in the production of nice staple and illustrates the fact by the case of Sea Island cotton.

Unfortunately there are no records of humidity for Navsari, where, as has already been stated, the best staple cotton in the tract is grown, but we have figures for Surat and can compare these with the data for other cotton growing countries. Dividing the growing period into two periods we have as follows :—

| | Humidity | |
|---|---|---|
| | April to August | September to November |
| | Per cent. | Per cent. |
| *America* | | |
| Mississippi .. .. | 83 | 82 |
| Texas .. .. | 82 | 80 |
| Georgia .. .. | 79 | 84 |
| *Egypt* | | |
| Cairo .. .. | 52 | 64 |
| *Surat* .. .. | 77* | 57† |

Orton, *U. S. Farmer's Bulletin* No. 302, p. 9 1907).

* June to September. † October to December.

The periods taken in the case of Surat and of the other tracts are slightly different, because the periods of growth are not quite the same. But they represent in each case, in the first column, the growing period of the plant, and in the second column, the flowering and boll forming period. They show a remarkable agreement between the humidity of the growing period at Surat and in the American cotton states, the figures being much higher than in Egypt. The flowering and boll forming period at Surat is, however, very much drier than in America and distinctly more so even than in Egypt. There is, in fact, a sudden decrease in humidity after September, as the following figures show :—

| Month | Humidity at Surat |
|---|---|
| | Per cent. |
| June .. .. .. .. | 73 |
| July .. .. .. .. | 78 |
| August .. .. .. .. | 79 |
| September .. .. .. | 78 |
| October .. .. .. | 57 |
| November .. .. .. | 57 |
| December .. .. .. | 59 |

Closely connected with the effect of temperature and humidity is the reported influence, in the region we are considering, of a cold north wind, locally called *himalu*, which tends to prevail at intervals from the latter part of December to the early part of February. During its prevalence the rapidity of development of the flowers is much reduced, and if the period coincides with the last stage of flowering, this suddenly ceases. The vigour of the plant also seems to be affected, as flowers producing bolls after such a period give seeds with a smaller weight than during the rest of the season.

### Method of growing *broach deshi* cotton.

With the soil and climatic conditions which has been described, the *broach deshi* cotton is grown in the following manner. The normal rotation is that of cotton and *jowar* (*Andropogon Sorghum*), and preparatory tillage for the cotton crop begins about the end of April by the harrowing of the fields to remove the stubbles of the previous crop. If manure is used in the rotation, it is usually applied in May or June, previous to the cotton crop, but this consists exclusively of cattle manure, and artificial manures have never been used, hitherto, on any large scale.

The seed is usually sown by a two-foot drill in June, at the first opportunity after the first rains. The seed rate is ten to twelve pounds per acre. In many

cases the first sowing fails, either owing to a break in the rains or, far more frequently, to excessive rain after sowing, and has to be repeated. After the plants have five or six leaves, they are thinned to a distance of one foot between the plants in the row. By this system the usual stand of plants obtained is about 75 per cent. The crop is intercultured with a blade harrow two or three times, and finally this process is repeated deeply in October either with the country plough or with the blade harrow.

The crop in a normal year flowers by December and the first crop of cotton is gathered at the beginning of March. It is harvested in three pickings. The normal crop of the Navsari-Surat area is 360 lb. of seed cotton per acre equal to about 110 to 120 lb. of clean cotton per acre.

The root system of cotton in South Gujarat is very deep, usually going to 3 to 3½ feet. The secondary root system is specially well developed, and commences from almost immediately below the surface level.

*Table showing the rainfall and the yield of kapas per acre at Surat.*

| Year | Total rainfall in inches | Yield in lb. | Remarks |
|---|---|---|---|
| 1897 .. .. .. | 39·02 | 351 | |
| 1898 .. .. .. | 30·84 | 175 | |
| 1899 .. .. .. | 18·47 | 116 | 16 inches of rain in 11 days in July. |
| 1900 .. .. .. | 34·19 | 87 | Severe bollworm attack. |
| 1901 .. .. .. | 16·80 | 129 | Average yield of the whole experimental area. |
| 1902 .. .. .. | 54·58 | 409 | |
| 1903 .. .. .. | 41·00 | 388 | |
| 1904 .. .. .. | 13·40 | 242 | 4·71 inches in July and 3·91 inches in September. |
| 1905 .. .. .. | 19·82 | 370 | 8 inches of rainfall within 12 days. |
| 1906 .. .. .. | 30·17 | 437 | |
| 1907 .. .. .. | 38·88 | 500 | Sown in September. Early setting in of cold in November. |
| 1908 .. .. .. | 47·45 | 426 | |
| 1909 .. .. .. | 53·31 | 397 | |
| 1910 .. .. .. | 32·09 | 415 | |
| 1911 .. .. .. | 17·30 | 91 | North-eastern winds with cloudy weather in November. |
| 1912 .. .. .. | 51·68 | 643 | |
| 1913 .. .. .. | 33·36 | 449 | |
| 1914 .. .. .. | 60·64 | 546 | |
| 1915 .. .. .. | 26·90 | 296 | |
| 1916 .. .. .. | 57·16 | 512 | |
| 1917 .. .. .. | 60·42 | 512 | |
| 1918 .. .. .. | 17·65 | 405 | 7·8 inches of fall one day. |
| 1919 .. .. .. | 41·97 | 371 | |
| 1920 .. .. .. | 20·02 | 631 | |
| 1921 .. .. .. | 48·23 | 440 | |

## II. THE HEREDITARY NATURE OF CERTAIN CHARACTERS IN *BROACH DESHI* COTTON.

In the author's previous Memoir he has discussed the question as to what characters are hereditary in *goghari* cotton. The general conclusions reached there for *goghari* cotton remain true for *broach deshi* cotton, but it is possible to consider the heredity of certain other characters, as the result of experiments more recently conducted.

### (*a*) Hereditary nature of length of internodes on the main stem and monopodia.

The shape and character of a plant very largely depends on the length of the internodes on the stem. Long internodes mean a tall and sparse plant, short internodes mean a short and bushy plant. In cotton this difference is of very great importance, so that the question as to how far a type of cotton selected for its tall sparse habit will remain so in successive generations is of more than academic interest. The importance is particularly great in the Surat black soil during the first part of the growth, when the mortality is apt to be very great in low growing types. In 1921-22, for example, the mortality during the continuous rain from July to September was greater with plants of these types. Kottur[1] considers that, in Dharwar, short internodes often injuriously affect the development of fruiting branches. On the other hand, Burt[2] has found in Northern India that plants with long internodes are usually straggling in general habit, and tend to produce long weak lateral branches.

The hereditary character of this feature has been considered by Bennet[3] who states that the length of the internode is chiefly controlled by the breeding of the type, and that while the water supply affects the length, it acts similarly on long and short jointed types of cotton. Cook[4] also calls attention to the definitely hereditary character of the feature under discussion.

The results which the author has obtained in the last three years have confirmed for *broach deshi* cotton in every respect the views expressed by Bennet. While the relative length of the internode in different pure types remains similar, the actual length varies enormously in different years. Thus

[1] *Bombay Dept. of Agri. Bull.* 106 (1920), p. 17.
[2] *Pusa Agri. Res. Inst. Bull.* 88 (1919).
[3] Bennet. Method of breeding early cotton to escape boll weevil damage. *U. S. Farmers Bull.* 314 (1908).
[4] Cook. *U. S. Dept. Agri. Bur. of Pl. Indus. Bull.* 159 (1909).

to take two pure lines of *broach deshi* cotton, the actual average length of the internodes on the main stem from the first to the sixteenth internode was as follows :—

| Strain | Length of internode at Surat | | |
|---|---|---|---|
| | 1919–20 cm. | 1920–21 cm. | 1921–22 cm |
| 1-A Long Boll .. .. .. | 21·8 | 30·6 | 14·5 |
| 1-A Cylindrical Boll .. .. .. | 24·7 | 37·0 | 17·7 |

In 1919-20 the rainfall was heavy, with breaks; in 1920-21 the rain was in comparatively light showers, with breaks; in 1921-22 the rains were continuous and heavy from July to September. It will be seen that the relative difference is maintained, while the continuous rain of 1921-22 has reduced the length of the internodes enormously.

In this connection it is interesting to consider, in single strains, the relationship between the length of the several internodes on the monopodial branches, and the occurrence and length of the fruiting branches which arise from them. On these monopodia the fruiting branches arise (in the strains studied) chiefly from the fifth node and those beyond it. Wherever there is a short internode, however, the number of failures to form a branch at the succeeding node is very great, and this applies in the case of several strains. To ascertain how far the connection was a real one, the internodes on the monopodial branches of three strains, two of *broach deshi* and one of *goghari* were measured, and the success of branch formation at the succeeding nodes determined. One hundred or more plants were measured in each case, and the average taken.

| Position of internode | Length of internode | *Goghari* "B-3" Percentage of failure of branches | Length of internode | 1-A Long Boll. Percentage of failure of branches | Length of internode | 1-A Cylindrical Boll. Percentage of failure of branches |
|---|---|---|---|---|---|---|
| | cm. | | cm. | | cm. | |
| 4th to 5th .. | 2·7 | 7·7 | 2·5 | 1·0 | 2·6 | 6·0 |
| 5th to 6th .. | 2·2 | 91·4 | 1·9 | 96·9 | 1·9 | 93·0 |
| 6th to 7th .. | 2·8 | 74·7 | 2·3 | 71·8 | 2·3 | 70·8 |
| 7th to 8th .. | 3·4 | 8·6 | 3·0 | 2·2 | 2·9 | 6·3 |
| 8th to 9th .. | 2·5 | 91·9 | 1·9 | 98·4 | 1·9 | 91·2 |
| 9th to 10th .. | 3·8 | 10·4 | 3·3 | 2·2 | 3·2 | 5·5 |
| 10th to 11th .. | 3·4 | 12·9 | 2·7 | 11·1 | 2·6 | 15·9 |
| 11th to 12th .. | 3·2 | 73·9 | 2·2 | 88·1 | 2·4 | 77·7 |
| 12th to 13th .. | 4·1 | 3·5 | 3·4 | 1·7 | 3·3 | 4·9 |
| 13th to 14th .. | 3·3 | 39·8 | 2·1 | 61·9 | 2·2 | 47·2 |

Still another interesting connection appears to exist, at least in certain strains, between the length of the monopodial internodes, and the length (in nodes) of the fruiting branches (sympodia) which arise from them. Strains which have long monopodial internodes give short (few noded) fruiting branches and *vice versa*.

| | *Goghari* B-3 | 1–A Long Boll | 1–A Cylindrical Boll |
|---|---|---|---|
| | cm. | cm. | cm. |
| Average length of monopodial internode | 3·1 | 2·5 | 2·5 |
| Average number of nodes on fruiting branches from the monopodia .. | 1·6 | 1·7 | 2·4 |

This point, however, needs considerably extended observations before the general applicability of the principle can be maintained.

### (*b*) Hereditary nature of the length of petioles of leaves on the main stem.

The length of the leaf petioles is, of course, an exceedingly variable factor, depending on the vigour of the plants, the season in which they are grown, and the position of the leaf of the plant. Its close correlation with the size of the leaf blade, moreover, will be discussed later. But the relationship between the length of the petiole of leaves in a similar position on plants grown, side by side, seems constant, and hence the presumption is that we are in face of a hereditary character. The average length of the petioles of various leaves on the main stem in successive seasons (taken in each case from not less than 150 plants) is as follows, with two pure types of *broach deshi* cotton. The leaves are numbered from the base of the plants.

| Leaf number | Length of the petiole | | | | | |
|---|---|---|---|---|---|---|
| | 1–A Long Boll | | | 1–A Cylindrical Boll | | |
| | 1919–20 | 1920–21 | 1921–22 | 1919–20 | 1920–21 | 1921–22 |
| | cm. | cm. | cm. | cm. | cm. | cm. |
| 1 .. .. | .. | 2·18 | 1·3 | .. | 2·30 | 1·5 |
| 2 .. .. | .. | 2·25 | 1·4 | .. | 2·72 | 1·6 |
| 3 .. .. | .. | 2·52 | 1·7 | .. | 3·41 | 1·9 |
| 4 .. .. | .. | 2·72 | 1·8 | .. | 3·47 | 2·0 |
| 5 .. .. | .. | 2·79 | 2·1 | .. | 3·70 | 2·3 |
| 6 .. .. | .. | 2·85 | 2·4 | 2·96 | 4·04 | 2·6 |
| 7 .. .. | 2·74 | 2·86 | 2·6 | 3·09 | 4·13 | 2·7 |
| 8 .. .. | 2·86 | 3·13 | 2·7 | 3·30 | 4·27 | 2·8 |
| 9 .. .. | 3·03 | 4·00 | 2·7 | 3·68 | 5·30 | 2·9 |
| 10 .. .. | 2·96 | 4·40 | 3·1 | 3·93 | 5·70 | 3·5 |
| 11 .. .. | 3·12 | 4·76 | 3·2 | 4·27 | 6·00 | 3·7 |
| 12 .. .. | 3·20 | 5·08 | 3·3 | 4·35 | 6·30 | 4·0 |
| 13 .. .. | 2·96 | 5·30 | 3·5 | 4·35 | 6·30 | 4·2 |
| 14 .. .. | 2·76 | 5·44 | 3·8 | 4·30 | 6·80 | 4·3 |
| 15 .. .. | .. | 5·61 | 3·8 | .. | 6·90 | 4·4 |

### (c) Hereditary nature of the number of monopodia in a strain of cotton.

The number of monopodia in a plant determines in a very large measure its growing character, and hence the question as to whether the tendency to produce monopodia is hereditary is a matter which has been always considered of great importance. Leake[1] considers that it is one of the fundamental differences between various types of cotton and bases his classification of cottons to a considerable extent on the frequency of the occurrence of and the number of monopodia. Kottur[2] likewise insists on the stability of this character in the types of *kumpta* (*Gossypium herbaceum*) cotton which he studied, and Burt[3] gives similar results for some of the Cawnpore-American types studied by him. The experience of most of the American workers is similar, though they insist[4] on the very considerable variation induced in any one type by changes in environment.

Using the same criterion of the hereditary character of any feature of a strain which the author has previously employed, namely, the constant relationship of the character in two or more strains in successive years, the number of the monopodia has been determined in a series of at least one hundred plants of five different strains in 1919-20, 1920-21 and 1921-22. The results which follow show the modal value for the number of monopodia in each strain in each year.

| Strain | Number of monopodia (Modal value) | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| B–1 .. .. .. .. | 6 | 6 | 6 |
| C–1 .. .. .. .. | 5 | 5 to 6 | 5 |
| 1–A Long Boll .. .. .. | 5 to 6 | 7 | 7 to 8 |
| 1–A Cylindrical Boll .. .. | 6 | 7 to 8 | 8 to 9 |
| 1027–A. L. F. .. .. .. | 6 | 7 | 7 to 8 |

[1] *Agri. Jour. India*, X, p. 116, Pl. 2 (1915).

[2] *Poona Agri. Coll. Mag.*, X, No. 1.

[3] *Pusa Bull.* No. 88 (1919).

[4] Hudson. *Arkansas State Expt. St. Bull.* No. 168 (1920).

*U. S. Bureau of Plant Industry Bull.* No. 159 of 1909. Local adjustment of cotton varieties.

The results indicated in these figures are more strongly illustrated by a comparison of the frequency curves of the number of monopodia in the series studied, and the following two figures compared these for two of the years studied in two of the above types. The general result is to confirm, for the *broach deshi* cotton studied, the observations recorded by other workers for other cottons, that the tendency to form few or many monopodia is inherited.

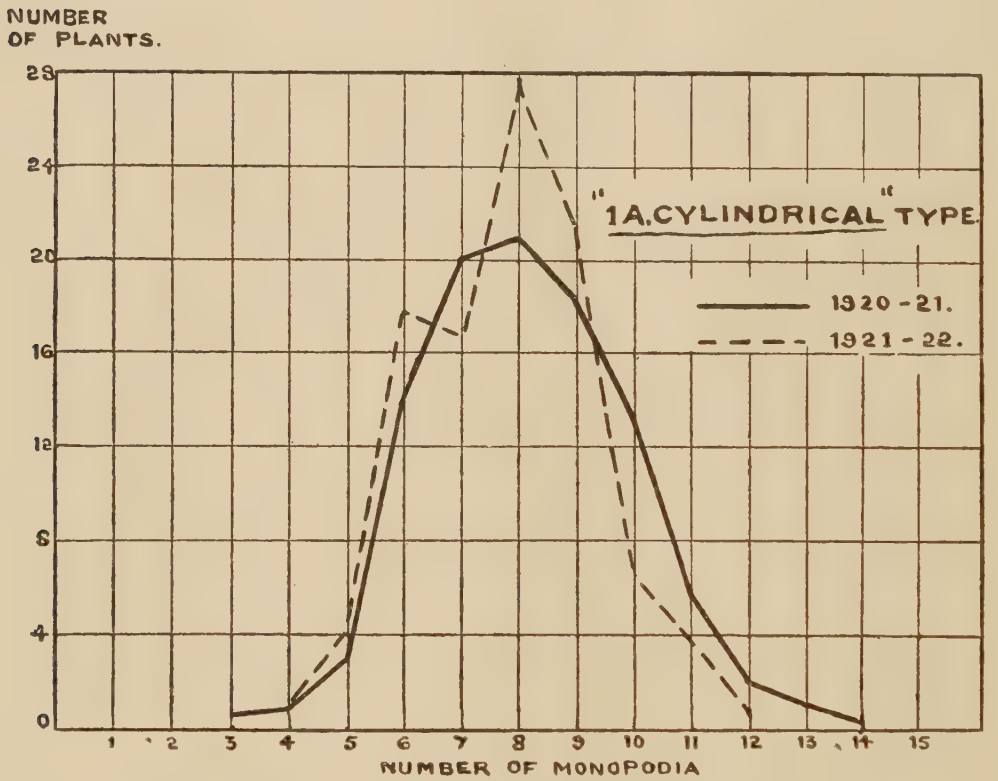



FIG. 1. Variation in the number of monopodia in 1920–21 and 1921–22.

### (*d*) HEREDITARY NATURE OF THE POSITION OF THE FIRST FRUITING BRANCH (SYMPODIUM) FORMED ON THE MAIN STEM.

Since a considerable proportion of the yield of cotton given by a plant is produced on fruiting branches (sympodia) borne on the main stem, and as this is the earliest cotton borne on the plant, it is obviously of considerable interest to know whether the faculty to form such branches at a particular position

in the plant is hereditary, and can be relied upon to recur from generation to generation. The actual position of the first fruiting branch, however, varies very widely in different cottons. In Sea Island cotton (*Gossypium*

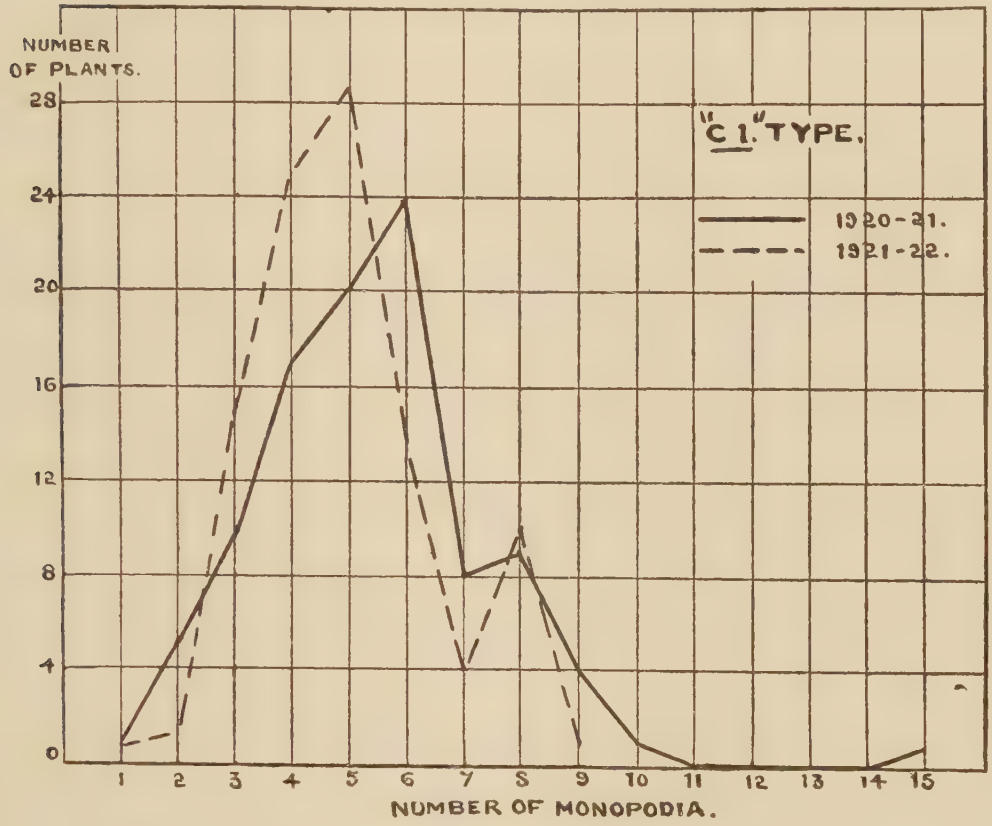



FIG. 2. Variation in the number of monopodia in 1920–21 and 1921–22.

*barbadense*) the first fruiting branch arises from the eighth to the fourteenth node[1], in American cotton (*Gossypium hirsutum*) it usually appears at the fifth or sixth node, in *kumpta* cotton[2] at Dharwar the point of origin is the seventh or eighth node.

In the author's experiments, three strains of *broach deshi* cotton have been studied for three years, and the position of the node from which the first

[1] *Agri. News, Barbados*, XIX, p. 101.
[2] *Mem. Dept. Agri. India, Bot. Ser.*, X, No. 6, p. 251 (1920).

fruiting branch arises determined for a series of plants all growing three feet apart. The modal value for the results is as follows :—

| Strain | Position of first fruiting branch (Modal value) | | |
|---|---|---|---|
| | 1919-20 | 1920-21 | 1921-22 |
| C-1 .. .. .. .. | 17 | 13 | 17 to 18 |
| 1-A Cylindrical Boll .. .. | 19 | 15 | 20 |
| 1-A Long Boll .. .. .. | 18 to 19 | 14 | 19 to 20 |

The variation, however, in one and the same season in a pure strain is fairly wide, and different plants growing under identical conditions vary by six to eight nodes. The co-efficient of variability in a single season with regard to the above three strains is :—

| Strain. | | |
|---|---|---|
| C-1 .. .. .. .. | 1920-21 .. | 12·8 |
| | 1921-22 .. | 7·0 |
| 1-A Cylindrical Boll .. .. | 1920-21 .. | 11·0 |
| | 1921-22 .. | 6·0 |
| 1-A Long Boll .. .. .. | 1920-21 .. | 11·5 |
| | 1921-22 .. | 6·6 |

The character is, therefore, very variable. The relative difference in the modal value is maintained, however, indicating the character to be of hereditary nature.

### (*e*) Hereditary nature of the shedding of flower buds.

The yield of cotton from any plant is determined by the number of sound bolls produced, but this number is often far less than the possible production. There is, in fact, in every type of cotton and under every condition of cultivation a loss of potential yield due to shedding of flower buds, flowers, or bolls during every stage of their growth. At present we will limit our consideration to the loss of flower buds. This loss varies in different cottons from almost *nil* in Egyptian cotton to nearly seventy per cent. in the *broach deshi* cotton which we are now considering.

In the *broach deshi* cotton in 1919-20, the loss at Surat was found to be 71·7 per cent., in the following year it was 60·8 per cent., and in 1921-22 it was 58·2 per cent. In American cotton it seems to vary between 14 and 17 per cent.[1] and in Sea Island cotton it may rise to from 40 to 50 per cent.[2]

[1] Lloyd. *Annals of New York Academy of Sciences*, Vol. **29**, pp. 82 and 84.
[2] *West Ind. Bull.*, XVIII, p. 191.

Naturally this loss is due to many causes. Attack by insects accounts for a certain proportion; unsuitable cultivation may lead to much loss; reduction in the moisture content in the soil also accounts for a certain amount of shedding. But in spite of the influence of all these and several other environmental conditions, the various types of cotton *do* seem to have varying capacity to mature the flower buds which they form.

In this connection a very interesting observation has been made by Harland[1] in the West Indies (St. Vincent). He found that, in certain types of native cotton, the tendency to shed flower buds was highly developed, and that when these were crossed with Sea Island cotton the feature appeared to be inherited as a dominant character. Again Cook[2] maintains that the faculty of shedding flower buds is a hereditary characteristic of certain brachytic types of cotton which he has described.

The general position with regard to the loss of flower buds in Lower Gujarat has been already noted and the seriousness of the loss on this account described. It may be worthwhile, however, giving the results of observations on the matter in more detail. In the first place, the number of flower buds, which are shed, varies very much in different parts of the season. The method of estimation was as follows. The number of flower buds formed up to a certain date (say 5th November) was counted. Other observations had shown that it required not more than a month for a flower bud to develop into a flower, and so all flowers formed up to one month later (say 5th December) were counted and the number compared with the number of flower buds. The results by this method in 1920-21 and 1921-22 are shown in the following table for a number of pure strains :—

| Strain | Percentage of flower buds forming flowers | | | |
|---|---|---|---|---|
| | 1920–21 | | 1921–22 | |
| | Buds formed to November 5th | Buds formed in whole season | Buds formed to December 9th | Buds formed in whole season |
| B–1 .. .. .. .. | 26·0 | 34·2 | 22·1 | 37·6 |
| C–1 .. .. .. .. | 17·0 | 39·0 | 26·1 | 40·3 |
| 1–A Long Boll .. .. .. | 7·8 | 39·3 | 19·5 | 39·7 |
| 1–A Cylindrical Boll .. .. .. | 14·2 | 43·2 | 33·3 | 46·1 |
| Selection 2 .. .. .. | 17·5 | 43·2 | 32·0 | 43·1 |
| 1027–A. L. F. .. .. .. | 11·3 | 36·5 | 28·2 | 44·1 |

[1] *West Ind. Bull.*, XVI, p. 74.

[2] Quoted by Lloyd, *Jour. Agri. Res.*, III (*February* 1915).

In the early part of the season, therefore, the loss of flower buds by shedding is apparently greater than in the latter part of the flowering period, and seems to vary very considerably in different strains grown under identical conditions. This difference between the success of the flower buds at different parts of the season seems, in Southern Gujarat, to depend mainly upon the period and virulence of bollworm (*Earias* spp.) attack and in the number of buds present when the bollworm attack is at its highest. There seems also to be a definite difference between the susceptibility of the strains to bollworm attack, as is illustrated by the behaviour of strain "B-1" in the above table, where it shows a very high proportion of success in the early part of the flowering (period of bollworm attack), but the lowest percentage of success taking the whole season together.

The case of this strain "B-1" is of special interest, for here the final low percentage of success appears to be due to the hereditary tendency to produce a larger number of flower buds in proportion to the vegetative growth than in any other case. This clustering together of the flower buds seems closely to be connected with the loss of buds, more particularly towards the end of the season when the water supply is short. The clustering together of flower buds can be said to exist when the number of flower buds on each fruiting branch is more or when the number of fruiting branches is more in relation to the growth in nodes of vegetative branches, *i.e.*, monopodia and axillary vegetative branches. These two can best be expressed together by comparing the ratio of the number of flower buds to the growth in number of nodes of vegetative branches (*i.e.*, monopodia and axillary vegetative branches). The difference between this and other strains is shown in the following table, indicating the ratio of the number of flower buds to nodes on the vegetative branches of the plant.

| Strain | Ratio of flower buds to nodes of growth | |
|---|---|---|
| | 1920–21 | 1921–22 |
| B-1 .. .. .. .. | 1·03 | 1·25 |
| C-1 .. .. .. .. | 0·54 | 1·17 |
| 1–A Cylindrical Boll .. .. | 0·50 | 0·90 |
| Selection 2 .. .. .. | 0·55 | 1·00 |
| 1027–A. L. F. .. .. .. | 0·60 | 0·88 |

Similarly the structure of the plant in certain cases as in " Selection 2 " (where the bracts have a very spreading character in the early stages), or in " C-1 " (where there is a more open habit of growth than in other strains) leads to a greater power of resisting the bollworm attack, and hence these strains give a large proportion of success in the earlier part of the flowering period. But making every allowance for all these environmental or structural differences, the relative position of the strains in the different years, so far as shedding of flower buds is concerned, remains sufficiently similar for us to say that there is certainly a hereditary factor involved in this case.

### (*f*) Hereditary nature of the shedding of flowers and young bolls.

But the shedding of potential cotton-producing organs is not limited to the flower buds. In the *broach deshi* cotton this is by far of the greatest importance, but there is also, here as elsewhere, a considerable amount of loss of flowers and young bolls.

The extent to which this loss of flowers and young bolls takes place varies very much. Lloyd (*l. c.*), to whom we owe one of the most illuminating studies of this question, found that in his work the percentage of loss in 1911 was 42·1, while in 1912 with American Upland cotton it was 28·0. A similar result was obtained with Sea Island cotton in the West Indies, where in 1916-17 only 17·2 per cent. of flowers produced bolls, 48 per cent. in 1917-18, and 37 per cent. in 1918-19.[1] In Egypt Balls[2] gives 60 per cent. as being the normal proportion of flowers which produce bolls.

The causes which lead to this enormous loss have been investigated by many workers, and it has been ascribed to root pruning by deep cultivation, to excessive vegetative growth during the flowering period, to heavy rain, to severe drought, to overcrowding of the plants, to insufficient pollination from whatever cause, to insect attack whether by aphis, bollworm or boll-weevil, and to a number of other causes. But as noted by the workers in Egypt, there is a variable amount of shedding under perfectly normal conditions, dependent on the actual strain in cultivation, which they term " constitutional shedding." This has also been noted elsewhere, and has been attributed by Foaden[3] to the development of a large number of flowers

[1] Harland. *West Ind. Bull.*, XVIII, p. 24.
[2] Balls. *The development and properties of raw cotton.*
[3] Foaden. *U. S. Bureau of Plant Industry Bull.* No. 62.

to leaf surface and by Kottur[1] to the bushy or erect character of the plants.

In the author's own experiments the various pure strains which he has isolated from *broach deshi* cotton have shown considerably different capacities to bring the flowers to maturity when grown under identical conditions. The actual results, in percentage of bolls to flowers which opened, in three years are as follows :—

| Strain | Percentage of ripe bolls to open flowers | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| B–1 .. .. .. .. | 40 | 31·5 | 29·5 |
| C–1 .. .. .. .. | 51 | 48·5 | 34 |
| 1–A Long Boll .. .. .. | .. | 38 | 32 |
| 1–A Cylindrical Boll .. .. | 53· | 40 | 32 |
| Selection 2 .. .. .. | 47 | 33·5 | 34 |
| 1027–A. L. F. .. .. .. | 49 | 36 | 38·5 |

The differences between the different seasons were great, and generally the percentage of ripe bolls to open flowers is much less than in Egypt. But the loss is also seen to be in a measure a matter of strain, and those strains which give a higher or a lower percentage of success in one season will also tend to give generally a higher or lower percentage in another year with very different climatic conditions. This does not always appear, but there is sufficient constancy in the relative position of the various types to justify the conclusion that the tendency to a great or less proportion of shedding of flowers and young bolls is a hereditary character, though it is very largely masked by the effect of different environmental factors.

While the question of flower and boll shedding is under consideration it may be noted that the flowers formed at different stages of the season have by no means the same chance of producing successful bolls. Observations on this point were made in both 1920-21 and 1921-22, and the

[1] *Bombay Dept. of Agri. Bull.* No. 106 (1920), p. 18.

following table shows the results with three pure strains in these two years :—

| Period of flowering | Flowers formed producing ripe bolls | | | | | |
|---|---|---|---|---|---|---|
| | B-1 | | 1-A Long Boll | | 1027-A. L. F. | |
| | 1920-21 | 1921-22 | 1920-21 | 1921-22 | 1920-21 | 1921-22 |
| | % | % | % | % | % | % |
| First three weeks .. | 40 | 21·5 | .. | 15 | .. | 57 |
| Fourth week .. | 79 | 38·5 | 63·5 | 16·5 | 72·5 | 50 |
| Fifth „ .. | 65 | 55 | 75 | 32 | 79 | 45 |
| Sixth „ .. | 49·5 | 61·5 | 72 | 56·5 | 69 | 65·5 |
| Seventh „ .. | 14 | 58 | 67 | 64·5 | 36 | 70 |
| Eighth „ .. | 3·5 | 58 | 38·5 | 63 | 18·5 | 58·5 |
| Ninth „ .. | 3·0 | 54 | 16 | 58 | 8·5 | 45 |
| Tenth „ .. | .. | 20 | 5 | 28·5 | 0·5 | 14 |
| Eleventh „ .. | .. | 2·5 | .. | 4 | .. | 1·5 |

The early flowers in most strains and the late flowers in all strains are very largely lost. The early loss seems chiefly due to the attack of bollworm and wherever bolls are produced from the flowers opening at this period the produce is always much attacked by this insect.

This is shown by the number of seeds per boll obtained at different parts of the season, a small number indicating that the remainder have been destroyed by insect attack. The following table gives observations on this point.

| Strain | Seeds per boll—(average) | | | |
|---|---|---|---|---|
| | To December 12th | December 13th to January 13th | Whole Season | Healthy bolls |
| 1 A Long Boll .. .. | 13·4 | 18·6 | 19·2 | 22·2 |
| 1027-A. L. F. .. .. | 8·4 | 15·5 | 16·4 | 21·0 |

The loss at the end of the flowering season may be due to water shortage, though on this point we have no evidence. But it is certain that at the time

when the percentage of successful bolls begins to go down, the seed weight also declines, leading consequently to a reduction of lint weight per seed and per boll.

One more point of interest arises in connection with the shedding of flowers and young bolls. Is the proportion of shedding affected by the class of branch on which the flowers are borne ? The following table shows the records made on this point in 1919-20, though it must be recognized that the effect of the character of the branch on which bolls are borne may easily have been masked by other factors. So far as the figures show anything, they indicate little influence of the branch bearing the flowers on their success.

| Strain | Percentage of successful flowers | | |
|---|---|---|---|
| | On primary fruiting branches | From monopodia | From axillary vegetative branches |
| Selection 2 .. .. | 44 | 50 | 47 |
| 1-A Cylindrical Boll .. .. | 57 | 51 | 55 |
| 1027-A. L. F. .. .. | 65 | 43 | 48 |
| C-1 .. .. .. | 50 | 50 | 51 |
| B-1 .. .. .. | 24 | 39 | 43 |

The general observations made in connection with the shedding of flower buds, of flowers and of bolls lead to a much higher conception of the loss on this account in South Gujarat than is usually held. The total percentage of loss, in all these forms with several pure strains, has been as follows :—

| Strain | Total loss by shedding (Percentage of bolls to flower buds) | |
|---|---|---|
| | 1920-21 | 1921-22 |
| B-1 .. .. .. .. | 10·7 | 11·0 |
| 1-A Long Boll .. .. .. | 14·8 | 12·7 |
| 1027-A. L. F. .. .. .. | 13·5 | 16·8 |

It is difficult to conceive that the percentage loss by shedding represents always over 83 per cent. of the flower buds formed, and with some strains may go up to 89 per cent. The importance of checking, at any rate, some portion of this loss, whether by the selection of less shedding strains or by measures to deal with the factors of environment which lead to it, obviously cannot be over-estimated.

### (*g*) Hereditary nature of early or late flowering.

The appearance of flowers and the rapidity of flowering depends on the successful growth of the flower buds formed. The course of normal flowering is usually something as follows. The seed is sown in June, the first flower buds appear from five to ten weeks later, and the first actual flowers open from the fifteenth week onward. The actual flowering lasts from eight to twelve weeks, approximately from November to the latter part of January, and bolls ripen from the beginning of March to the middle of April.

The proportion of the total flowers produced and borne in the last part of the flowering season is a measure of the lateness of the strain grown, and the following figures show for four of our *broach deshi* strains what has been found. The period of flowering in different years is not the same owing to the variable weather conditions, but in 1919-20 and 1921-22, the last two weeks during which flowers were formed in any of the strains studied were the twenty-eighth and twenty-ninth weeks from germination. In 1920-21, the period of growth was shorter and the flowering ceased after the twenty-second or twenty-third week from the time of germination.

| Strain | Proportion of total flowers produced in the last two weeks | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| C-1 .. .. .. | 14·7 | 35·1 | 9·0 |
| 1–A Long Boll .. .. | 20·2 | 44·0 | 15·4 |
| 1–A Cylindrical Boll .. .. | 10·1 | 43·3 | 12·4 |
| Selection 2 .. .. .. | 14·7 | 30·8 | 3·1 |

The strain " 1-A Long Boll " retains its position as the latest type of these cottons throughout these seasons though they are different fundamentally in character, and the relative position of the others is very largely maintained. The evidence of these figures is, therefore, that the character of earliness or lateness of flowering is hereditary, though the actual dates of flowering are much modified by the environment in any specific season.

### (*h*) Hereditary nature of the size and shape of the bolls.

In the author's previous Memoir, it was shown that the size of the boll was hereditary in *goghari* cotton, taking the quantity of *kapas* per boll as a measure of the size. This is not a perfect measure of the size owing to the occurrence of three and four celled bolls. The latter are larger in size, but the extra number of seeds and hence the extra amount of *kapas* they contain is by no means proportionate to the increase in size. In one of the *broach deshi* strains ("B-1") a large number of three-celled and four-celled bolls were examined in 1920-21 and in two others ("1-A Long Boll" and "1027-A.L.F.") in 1921-22, and the extra number of seeds in the four-celled bolls determined. The results were as follows :—

| Strain | | Number of seeds | |
|---|---|---|---|
| | | 3–celled boll | 4–celled boll |
| B–1 | (1920-21) | 19·6 | 24·7 |
| 1-A Long Boll | (1921-22) | 22·3 | 26·5 |
| 1027 A. L. F. | (1921-22) | 22·3 | 28·3 |

Thus the addition of approximately 33 per cent. to the size of the boll has led to an increase in number of seeds of 26 per cent. with "B-1," of 19 per cent. with "1-A Long Boll" and of 27 per cent. with "1027-A.L.F." A similar variation due to the presence of four-celled bolls has been noticed by Wells[1] in 1919 and Gilpin in 1920. As this variable factor occurs, it is necessary to investigate the extent to which the frequency of four-celled bolls is hereditary before the size of the bolls can be used as a measure of the relative amount of *kapas* they are capable of giving. The matter has been studied in five strains of *broach deshi* cotton in 1920-21 and 1921-22 with the following results :—

| Strain | Percentage of 4-celled bolls | |
|---|---|---|
| | 1920–21 | 1921–22 |
| 1027-A. L. F. | 23·0 | 13·8 |
| 1–A Long Boll | 17·0 | 5·8 |
| C-1 | 11·0 | 2·9 |
| Selection 2 | 5·0 | 1·2 |
| 1–A Cylindrical Boll | 1·0 | 0·3 |

[1] *Jour. Agri. Res.*, XXI, p. 238.

These figures show that the relative position of the strain in this particular is maintained, although the proportionate reduction is not equal with the different ones. The character is obviously hereditary, and the relative size of the bolls in different types of cotton may be used as a rough measure of the relative yield of *kapas*. Taking one hundred bolls in each case, the amount of *kapas* obtained in each of the last three years was as follows, with the five strains named below.

| Strain | Quantity of *kapas* per 100 bolls | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| | grm. | grm. | grm. |
| 1027–A. L. F. .. .. | 214·9 | 222·3 | 234·0 |
| 1–A Long Boll .. .. | 226·6 | 239·8 | 251·5 |
| C-1 .. .. .. | 165·2 | 169·6 | 191·8 |
| Selection 2 .. .. .. | 198·9 | 204·7 | 231·6 |
| 1–A Cylindrical Boll .. .. | 203·2 | 198·9 | 224·6 |

The relative difference is maintained year after year in all the strains except in " Selection 2 " in 1919-20, in comparison with " 1-A Cylindrical Boll." The difference in these in any year is, however, very small, probably less than the error of sampling.

One more point of interest arises in connection with the relative size of bolls as affected by the type of branches on which they are borne. Kottur has stated (*l. c.*) that in *kumpta* cotton nine bolls on primary fruiting branches (sympodia) are normally equal to ten on secondary fruiting branches borne on monopodia and to twelve on fruiting branches arising from axillary vegetative branches. This was studied in one of the *broach deshi* types (" 1-A Long Boll ") in 1919-20, with the following results, based on actual measurement of the bolls in each case. The length of the bolls was taken from the gland to the tip of one of the cells, and the width was the greatest width of the cell of a boll.

| Kind of branches | Length of boll | Width of cell |
|---|---|---|
| | cm. | cm. |
| (1) Bolls on primary fruiting branches .. | 3·6 | 2·2 |
| (2) Bolls from monopodia .. .. | 3·6 | 2·2 |
| (3) Bolls from axillary vegetative branches .. | 3·7 | 2·2 |

Hence, the difference noticed by Kottur does not seem to occur, and in this strain the bolls are of very nearly equal size on whatever part of the plant they are borne.

In 1919-20 only two measurements were made, namely, the length from the gland to tip and the greatest width of the bolls. The whole records for each of the pure types of *broach deshi* cotton as grown in Surat are shown in the accompanying table. This distinctly shows that the relative difference is maintained.

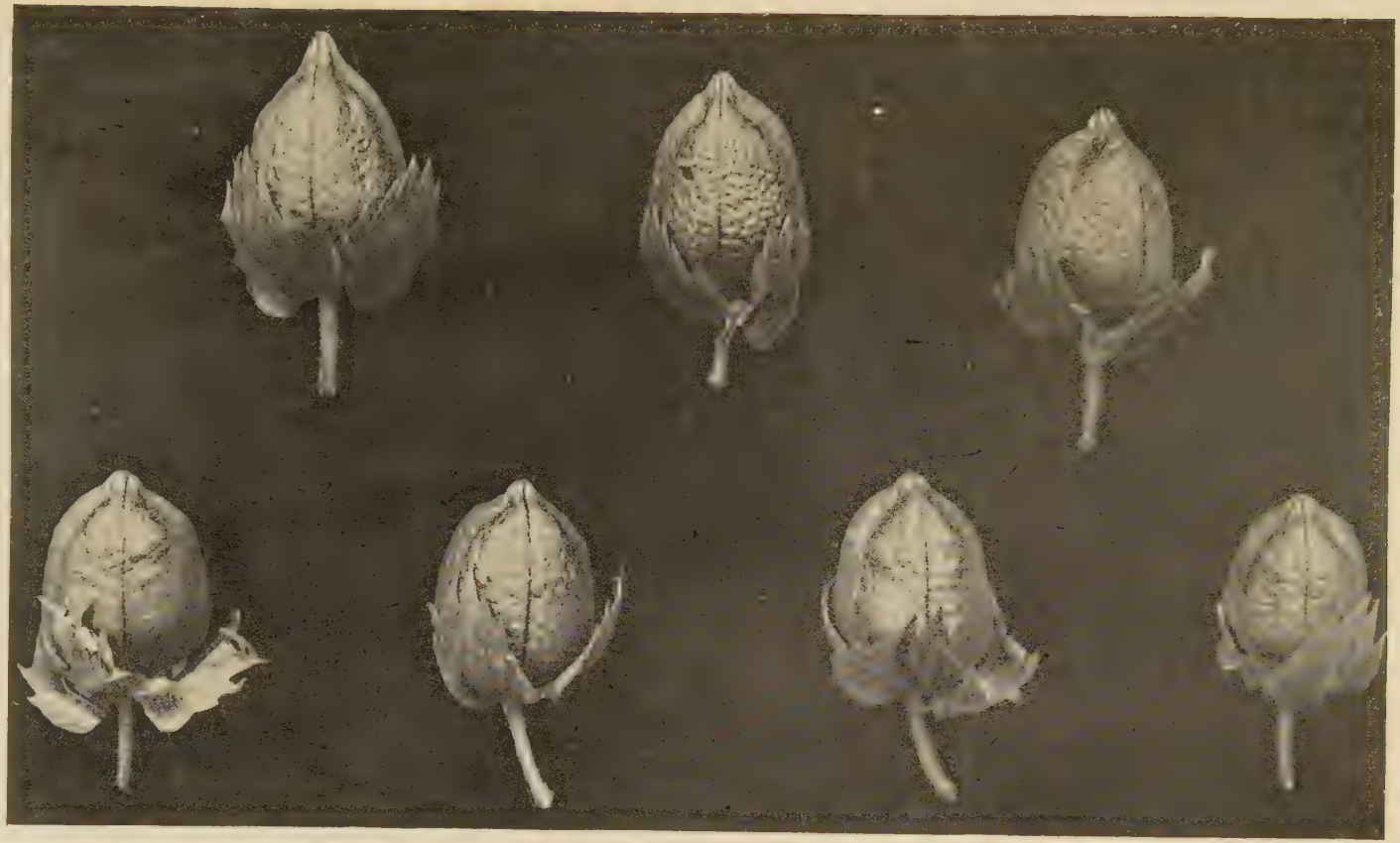
| Strain | Measurement of bolls | | | | | |
|---|---|---|---|---|---|---|
| | Length from gland to tip | | | Greatest width of one cell | | |
| | 1919–20 | 1920–21 | 1921–22 | 1919–20 | 1920–21 | 1921–22 |
| | cm. | cm. | cm. | cm. | cm. | cm. |
| 1–A Long Boll .. | 3·8 | 3·6 | 3·6 | 2·4 | 2·2 | 2·2 |
| 1027–A. L. F. .. | 3·6 | 3·4 | 3·4 | 2·2 | 2·1 | 2·2 |
| 1–A Cylindrical Boll .. | 3·2 | 3·2 | 3·1 | 2·2 | 2·1 | 2·1 |
| Selection 2 .. | 3·2 | 3·1 | 3·1 | 2·2 | 2·2 | 2·2 |
| C–1 .. .. | 3·1 | 2·9 | 3·0 | 2·0 | 2·0 | 2·0 |
| B–1 .. .. | 2·9 | 2·9 | 2·9 | 2·0 | 2·0 | 2·0 |

While we have the constancy of type in the bolls of the same pure strain, from year to year, the ordinary *broach deshi* cotton grown is very variable indeed. Plate I shows the type of boll represented by the different strains considered in the present paper. The experience gained with each of these pure strains for a series of years bears, however, no doubt as to the hereditary character of the shape and size of the boll in each of them.

### (*i*) Hereditary nature of the length of the seed hairs (staple).

The variation in the length of the seed hairs, even in a uniform pure type, has been long known to be very great, but there seems in each case a limit to the variability. Balls[1] from his work in Egypt considers that every strain

[1] Balls. *Mendelian studies in Egyptian cotton.*



TYPES OF BOLL IN BROACH DESHI COTTON.

Upper row (left to right)

(1) Boll of strain "1-A-Long Boll."
(2) and (3) Bolls of strain "1027, A.L.F."

Lower row (left to right)

(1) Boll of strain "Selection 2" spreading bracts.
(2) Boll of strain "1-A. Cylindrical Boll"
(3) Taper and small boll of strain "C-1."
(4) Small and almost cylindrical Boll of strain "B-I."

PLATE I.

of cotton has the property of forming seed hairs of a minimum length, and that this will not vary more than 25 per cent. under extreme conditions. He[1] also has found that the first pickings in Egypt give long lint, while from the later pickings, various lengths may be found in different seeds from the same boll. He[2] also maintains that variation in the water content of the soil at certain stages after the opening of the flower, whether from variations in temperature or otherwise, affect the length of the seed hairs, as the growth of the hairs is at its maximum between the fifteenth and twenty-first day after the flower opening. Further, the length of the lint varies with the position of the seed in the boll, and the position of the lint hairs on different seeds.

These last points have also been noticed by other workers. Cook[3] states that in Upland American cotton long hairs occur at the end of the seed and short fibres at the base. In Egyptian cotton (*Metafifi*) the longest fibres are found in the middle of the seed and short fibres on the ends. Kottur (*l. c.*) in *kumpta* cotton has found that the tip of the seed bears short hairs and the base bears long ones. The seeds at the apex of the cells of the boll also produce shorter hairs than other seeds in the same boll.

The observations which have been made in connection with the present study of *broach deshi* cotton indicates that the seeds from the middle of the boll always have longer hairs, while those at the bottom, and specially on the side of the seed facing the base of the boll, have hairs of inferior length. The difference in the length of hairs from the different parts of the boll is shown by the following measurements.

| | |
|---|---|
| Mean length of lint hairs from seed at middle of boll (mean of 280 observations) .. .. .. | 2·4 cm. |
| Mean length of lint hairs from seed at the base of a lock .. | 2·2 cm. |

The relative length of the lint hairs from different parts of the same seed in the *broach deshi* cotton types is slightly different from that described by Kottur for the other variety of *Gossypium herbaceum* which he studied. The hairs at the tip are the shortest, while those in the middle are the longest.

As regards the variation in length in the different parts of the season, as represented by the first, second and third pickings, the following figures show

[1] Balls. *Notes on Mendelian heredity in cotton* at Cairo.
[2] Balls. *The development and properties of raw cotton*, p. 115.
[3] *U. S. Bur Plant Industry Bull.*, No. 156, p. 16.

the differences in the mean length in the different parts of the seed, for three pure strains.

| Strain | Mean length of seed hairs | | |
|---|---|---|---|
| | First picking | Second picking | Third picking |
| | cm. | cm. | cm. |
| | 1. Tip of the seed. | | |
| 1027–A. L. F. | 2·1 | 2·0 | 1·9 |
| Selection 2 .. .. | 2·1 | 2·1 | 1·9 |
| C-1 .. .. .. | 1·7 | 1·7 | 1·7 |
| | 2. Middle of the seed. | | |
| 1027–A. L. F. .. .. | 2·6 | 2·5 | 2·3 |
| Selection 2 .. .. .. | 2·4 | 2·5 | 2·3 |
| C-1 .. .. .. | 2·1 | 2·0 | 2·0 |
| | 3. Base of the seed. | | |
| 1027–A. L. F. .. .. | 2·4 | 2·3 | 2·2 |
| Selection 2 .. .. .. | 2·3 | 2·4 | 2·2 |
| C-1 .. .. .. | 2·0 | 2·0 | 1·9 |

From these figures, it is evident that the hairs from the first picking are usually the longest, though the produce of the second picking is very little less in length. The last picking is, however, uniformly inferior in staple.

The variation in the length of the staple in the produce of different kinds of branches was studied in two of the pure strains in 1919-20 with the following results: —

| Strain | Mean length of seed hairs | | |
|---|---|---|---|
| | On primary fruiting branches | On branches arising from limbs | On branches arising from axillaries |
| | cm. | cm. | cm. |
| | 1. Tip of the seed. | | |
| 1–A Long Boll .. .. | 2·2 | 2·1 | 2·2 |
| 1–A Cylindrical Boll .. .. | 2·2 | 2·0 | 2·2 |
| | 2. Middle of the seed. | | |
| 1–A Long Boll .. .. | 2·5 | 2·4 | 2·5 |
| 1–A Cylindrical Boll .. .. | 2·5 | 2·4 | 2·5 |
| | 3. Base of the seed. | | |
| 1–A Long Boll .. .. | 2·3 | 2·2 | 2·3 |
| 1–A Cylindrical Boll .. .. | 2·4 | 2·3 | 2·4 |

The staple of the produce from the fruiting branches borne on the primary monopodia (limbs) is very slightly shorter than from the bolls borne on the other two types of branches. This clearly proves that the increase or decrease in the number of limbs in different strains of a variety will only very slightly affect this character.

The system of measurement of the staple of the lint hairs produced by a type of cotton is a matter of importance in any critical study of this question. Harland measures it on five seeds of each type. Balls recommends that seven seeds of each type should be used for the purpose and the average taken, while the West Indies authorities advise that ten seeds taken at random should be employed, the average of these being taken as before. The author has adopted the system of measuring the lint on the seeds in half of a cell, taken from three bolls to be chosen from all pickings of a single plant when the comparison is to be made of the produce of individual plants of a strain. When comparisons of strains are to be made, the hairs of one hundred seeds are measured, again all the seeds of half a cell being taken. The measurements are always taken at the tip, the middle and the base of each seed.

Using this method, it is possible to get very reliable results in testing whether the relative length of the lint hairs in different strains is maintained in different years and so a determination made as to whether this character is hereditary or not. The actual results with five pure strains are as follows :—

| Strain | Average length of seed hairs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1919–20 | | | 1920–21 | | | 1921–22 | | |
| | Tip | Middle | Base | Tip | Middle | Base | Tip | Middle | Base |
| | cm. | cm. | cm. | cm. | cm. | cm. | cm. | cm. | cm. |
| 1027–A. L. F. .. .. | 2·2 | 2·7 | 2·4 | 2·0 | 2·5 | 2·3 | 2·4 | 2·9 | 2·8 |
| 1–A Long Boll .. .. | 2·3 | 2·5 | 2·4 | 2·0 | 2·5 | 2·5 | 2·1 | 2·6 | 2·6 |
| 1–A Cylindrical Boll .. | 2·2 | 2·5 | 2·4 | 1·7 | 2·2 | 2·1 | 2·1 | 2·6 | 2·6 |
| Selection 2 .. .. | Not ascertained | | | 2·0 | 2·4 | 2·3 | 2·1 | 2·5 | 2·4 |
| C-1 .. .. .. | Do. | | | 1·7 | 2·0 | 2·0 | 2·0 | 2·5 | 2·4 |

From these figures it will be seen that there are wide variations in staple of the cotton produced by a pure strain from season to season. In 1920-21, a dry season, the shortest staple was obtained, though the reduction was much greater in some types (as for example, " 1-A Cylindrical Boll ") than in others

(as for example, " 1-A Long Boll "). The type producing the longest staple (" 1027-A.L.F.") is, however, the longest throughout, and likewise that producing the shortest (" C-1 ") is the shortest throughout. Thus in spite of seasonal variation, the relative difference is maintained, and the character is definitely of hereditary nature.

### (*j*) Hereditary nature of the seed weight.

Workers with other species and varieties of cotton have already determined that with their types the seed weight is a definitely hereditary character. Balls[1], for example, has found this with Egyptian cotton, and Harland has stated that there is a strong correlation between the parent and the mean of the progeny in respect of the characters of the lint length, lint weight, and seed weight. In the author's own previous work he has adduced evidence that the seed weight is hereditary in the *goghari* variety of *Gossypium herbaceum*, but the matter is worthy of further discussion on the basis of observations made on *broach deshi* cotton at Surat.

In a pure strain the weight of the seed may vary from a number of causes :—

(1) Partially malformed plants give light seed.

(2) Seeds from badly opened bolls are light, whatever may be the causes of the bad opening of the bolls. Such bad opening is most frequently due to insect attack.

(3) Seeds from four-celled bolls are usually lighter than those from three-celled bolls.

(4) The previous treatment of the land as regards manure or rotation seems to have some effect. Thus cotton following green manuring of the land with sann-hemp (*Crotalaria juncea*) combined with fallow, gives heavier seeded cotton than when, as is usual in Surat, the cotton crop follows *jowar* (*Andropogon Sorghum*). The following figures illustrate the last of these points :—

| | Average weight of seeds | |
|---|---|---|
| | 1916–17 | 1917–18 |
| | mg. | mg. |
| Cotton after sann-hemp and fallow .. | 55·1 | 59·1 |
| Cotton after *jowar* .. .. .. | 49·8 | 57·3 |

[1] Balls. *Cotton Plant in Egypt*, 1912, p. 167.

There is also some evidence that cotton following groundnut gives lighter seed than when it follows *jowar*, but the results are not yet certain.

(5) The different pickings of the cotton give *kapas* with varying seed-weight. In this matter the following represents the results of three seasons.

| Strain | Average weight per seed in 1919–20 | | |
|---|---|---|---|
| | First picking | Second picking | Third picking |
| | mg. | mg. | mg. |
| B–1 .. .. .. | 55·7 | 51·0 | .... |
| C–1 .. .. .. | 52·2 | 50·6 | 49·3 |
| 1–A Long Boll .. .. | 61·9 | 60·0 | .... |
| 1–A Cylindrical Boll .. .. | 60·0 | 55·4 | .... |
| Selection 2 .. .. .. | 61·2 | 59·7 | 56·5 |
| 1027–A. L. F. .. .. | 66·0 | 62·2 | 60·6 |
| | Average weight per seed in 1920–21 | | |
| B–1 .. .. .. | 54·1 | 50·4 | 43·1 |
| C–1 .. .. .. | 56·2 | 55·1 | 45·8 |
| 1–A Long Boll .. .. | 69·6 | 67·2 | 60·9 |
| 1–A Cylindrical Boll .. .. | 59·0 | 57·3 | 56·5 |
| Selection 2 .. .. .. | 64·5 | 64·6 | 63·8 |
| 1027–A. L. F. .. .. | 62·2 | 61·2 | 59·6 |

From these figures, it is clear that there is a progressive decline in the seed weight through the season. This rule has practically no exception though the amount of such decline is very different in different types and in the different years. This point was made particularly clear in the results of 1921-22 where the seeds in the bolls produced from flowers in the last weeks of flowering (10th and 11th weeks) were compared with the average of the season. The fall from the average of the seeds in question was as follows :—

| Strain | Decrease in seed weight from flowers in the | |
|---|---|---|
| | 10th week | 11th week |
| | mg. | mg. |
| B–1 .. .. .. .. | 5·7 | No crop |
| C–1 .. .. .. .. | 5·5 | Do. |
| 1–A Long Boll .. .. .. | 3·8 | 7·0 |
| 1–A Cylindrical Boll .. .. .. | 5·9 | No crop |
| Selection 2 .. .. .. | 4·8 | Do. |
| 1027–A. L. F. .. .. .. | 7·8 | Do. |

Despite all these causes of variation, there is no doubt, as the following table indicates, that the heavy seeded strains (like " 1027-A. L. F.") and the light seeded strains (like " B-1 " and " C-1") maintain their respective characters, and that the character is definitely hereditary in these strains of *broach deshi* cotton.

Besides this, it will be seen that different seasons have a varying effect on the seed weight on different types. Each average weight given is from two thousand seeds.

| Strain | Average weight per seed | | | |
|---|---|---|---|---|
| | 1918–19 | 1919–20 | 1920–21 | 1921–22 |
| | mg. | mg. | mg. | mg. |
| B–1 .. .. .. .. | 55·1 | 54·0 | 52·9<br>51·3 | 55·4<br>55·1<br>51·3 |
| C–1 .. .. .. .. | 50·4 | 50·4 | 55·4<br>52·4<br>52·2 | 55·4<br>51·3<br>48·5 |
| 1–A Long Boll .. .. .. | 61·2 | 59·4 | 61·5<br>64·2<br>60·6 | 65·1<br>64·6<br>63·2 |
| 1–A Cylindrical Boll .. .. .. | .. | 59·7<br>58·5 | 56·8<br>56·5<br>55·7 | 64·6<br>64·2<br>62·2 |
| Selection 2 .. .. .. | 60·9 | 60·3 | 62·5 | 63·9<br>64·6 |
| 1027–A. L. F. .. .. .. | 63·2 | 63·2 | 64·2<br>67·0 | 74·5<br>69·2<br>67·2 |

### (*k*) Hereditary nature of the weight of lint per seed (lint index).

It will be shown later (Chapter III) that there is a reliable positive correlation between the mean weight of lint per seed and the mean weight of the seed itself in the strains of *broach deshi* cotton with which we are dealing, and that hence a larger seed has a greater potential lint bearing capacity. But for the moment, let us consider the actual weight of lint per seed in the lint

index as a factor independent of the weight of the seed itself. A detailed analysis of the character indicates that it depends on three factors :—(1) The number of lint hairs, (2) the length of the individual hairs, and (3) the thickness of the hairs. Of these, the first is the most important. If the number of lint hairs, that is to say, if the surface of the seed and the frequency of the hairs, is the same, the lint index depends on the length and thickness of the fibres. In selecting plants by lint index, therefore, care has to be taken that the raising of this index does not merely mean increasing the coarseness of the fibres.

The variation in the lint index in different parts of the season with pure strains of *broach deshi* cotton are shown by the following data for the different pickings in 1919-20 and 1920-21.

| Strain | Lint Index.* | | | |
|---|---|---|---|---|
| | 1st picking | 2nd picking | 3rd picking | 4th picking |
| | | 1919–20 | | |
| | grm. | grm. | grm. | grm. |
| B–1 .. .. | 2·6 | 2·6 | .... | .... |
| C–1 .. .. | 2·2 | 2·5 | 2 6 | .... |
| 1–A Long Boll .. | 3·6 | 4·1 | .... | .... |
| 1–A Cylindrical Boll .. | 2·9 | 3·2 | .... | .... |
| Selection 2 .. .. | 3·0 | 3·5 | 3·4 | .... |
| 1027-A. L. F. .. .. | 2·7 | 3·1 | 3·0 | .... |
| | | 1920–21 | | |
| B–1 .. .. | 2·9 | 2·8 | 2·2 | .... |
| C–1 .. | 3·1 | 3·1 | 2·6 | .... |
| 1–A Long Boll .. | 4·3 | 4·2 | 4·0 | 3·4 |
| 1–A Cylindrical Boll .. | 3·9 | 3·7 | 3·7 | 3·0 |
| Selection 2 .. .. | 3·8 | 4·0 | 3·9 | .... |
| 1027 A. L. F. .. .. | 3·4 | 3·6 | 3·5 | .... |

The variation not only in the index itself, but also in the relationship between the lint index at different parts of the season is very great. In 1919-20, the second picking gives in almost all cases a higher figure than the first and the third is nearly as high as the second. In 1920-21, on the other hand, the first and the second pickings differ little and the later ones are distinctly lower. A lower index at the end of the season seems a regular thing, for in 1921-22, the seeds in the bolls produced from flowers in the last week of flowering (10th and 11th weeks) gave consistently a considerable

* Weight of lint per 100 seeds (according to the usual standard).

decrease in the lint index on the average for the season. The actual figures were as follows :—

| Strain | Decrease in lint index from flowers in the | |
|---|---|---|
| | 10th week | 11th week |
| | grm. | grm. |
| B–1 .. .. .. .. | 0·18 | .... |
| C–1 .. .. .. .. | 0·27 | .... |
| 1–A Long Boll .. .. .. | 0·21 | 0·56 |
| 1–A Cylindrical Boll .. .. | 0·19 | .... |
| Selection 2 .. .. .. | 0·30 | .... |
| 1027-A. L. F. .. .. .. | 0·33 | .... |

Though the variability in the lint index is greater than has generally been realized, yet it seems clear that the strains with a high amount of lint per seed maintain their relative positions in different years, and that hence this character is hereditary. The following table shows how this relative position has been kept up in four successive seasons of strains with markedly different characters.

| Strain | Lint index | | | |
|---|---|---|---|---|
| | 1918–19 | 1919–20 | 1920–21 | 1921–22 |
| | grm. | grm. | grm. | grm. |
| B–1 .. .. .. .. | 2·9 | 2·7 | 2·9 | 2·8 |
| | | | 2·7 | 2·9 |
| C–1 .. .. .. .. | 2·8 | 2·4 | 2·7 | 2·9 |
| | | | 3·0 | 2·7 |
| 1–A Long Boll .. .. .. | 4·0 | 3·8 | 3·9 | 4·4 |
| | | | 4·2 | 4·3 |
| | | | | 4·2 |
| 1–A Cylindrical Boll .. .. | .... | 3·7 | 3·6 | 4·0 |
| | | | 3·7 | 3·5 |
| | | | | 3·9 |
| Selection 2 .. .. .. | 4·0 | 3·3 | 3·8 | 4·2 |
| | | | 3·9 | 4·6 |
| 1027-A. L. F. .. .. .. | 3·5 | 3·0 | 3·5 | 3·7 |
| | | | 3·7 | 3·9 |

Though the general relative position remains constant the variation in the strains is by no means equal. Thus in " 1029-A.L.F." and in " Selection 2 " the variations are very high indeed, and the reduction in the lint index in the year with late rainfall (1919–20) was much greater than with other types.

## III. THE CORRELATION OF CERTAIN CHARACTERS IN *BROACH DESHI* COTTON.

We have discussed in some detail the variability of some of the more important characters in pure strains of *broach deshi* cotton. It remains to see whether the development of some of these or other characters is correlated with that of others. The matter is of considerable importance in the breeding of useful cottons, as by this means it can be ascertained whether or not any particular combination of qualities is likely to be obtainable. Further, an easily observable character may possibly be used to judge the development of another which can less easily be determined, if they are found to be closely correlated.

### (*a*) Correlation between length of petioles and greatest breadth of the leaf.

It is a matter of some importance, especially in a region of heavier rains than are usual in cotton growing areas, that the leaf blade should not be too large and wide. In American cottons, its importance is recognized, for Bennett[1] has stated that "the largest leaves should not be wider than five or six inches across, at right angles to the midrib, because if otherwise, it prevents the drying of the lower bolls, and where the plant is large, it causes the loss of bolls by rotting."

The actual measurements on which the present correlation study is based were made on measurements of the third, fourth, fifth and sixth leaves from the base of the main stem, and involved measurements of 1,129 leaves of *broach deshi* types and 397 leaves of *goghari* types. The frequency variation of these characters is given in the accompanying statements. (Appendices I and II). The results in actual co-efficients were as follows :—

| Leaf number | Co-efficient of correlation | Probable error |
|---|---|---|
| | *Broach deshi* type | |
| (1) Third from base .. .. | + 0·71 | ± 0·02 |
| (2) Fourth „ „ .. .. | + 0·75 | ± 0·017 |
| (3) Fifth „ „ .. .. | + 0·75 | ± 0·017 |
| (4) Sixth „ „ .. .. | + 0·83 | ± 0·014 |
| | *Goghari* type | |
| (1) Third from base .. .. | + 0·69 | ± 0·029 |
| (2) Fourth „ „ .. .. | + 0·75 | ± 0·025 |
| (3) Fifth „ „ .. .. | + 0·69 | ± 0·032 |

[1] Bennett. *U. S. Dept., Agri. Farmers' Bull.* No. 314, p. 15 (1908).

These figures show that there is a strong positive correlation between the two measurements quoted.

### (*b*) Correlation between the weight of the cotton seed and the size of the boll.

It has been established already that there is a relation between the size of a cotton boll and the weight of the *kapas* per boll, and also that the diameter of the boll very largely determines its size if the number of cells remains the same. Now the weight of *kapas* per boll may depend (1) on the number of seeds, (2) on the weight of each individual seed, and (3) on the weight of lint per seed. It will be shown later that there is a positive correlation between the weight of seed and weight of lint attached to it. Therefore if it is proved that the number of seeds per boll is not less when the bolls are smaller (that is, when the boll diameter is less and the width of each cell is less), a positive correlation between size of the boll and weight of the cotton seed is established.

Such a correlation has been established by Hudson[2] in American cotton. The following figures show from three strains of *broach deshi* cotton and from the three successive years, the number of seeds per hundred bolls, and the weight of *kapas* in the same bolls.

| Strain | 1919–20 | | 1920–21 | | 1921–22 | |
|---|---|---|---|---|---|---|
| | Seeds in 100 bolls | Weight of *kapas* in 100 bolls | Seeds in 100 bolls | Weight of *kapas* in 100 bolls | Seeds in 100 bolls | Weight of *kapas* in 100 bolls |
| | | grm. | | grm. | | grm. |
| C-1 .. .. | 1937 | 165·2 | 1972 | 169·6 | 2048 | 191·8 |
| Selection 2 .. | 1877 | 198·9 | 1775 | 204·7 | 1964 | 231·6 |
| 1-A Cylindrical Boll | 1945 | 203·3 | 1956 | 203·3 | 2026 | 224·6 |

These figures show several points. In the first place, the strain in which the seeds are smaller (" C-1 ") does not contain less seeds than either of the other two. The number of seeds varies greatly in " Selection 2 "; because

here in some seasons as in 1920-21 the fertilization (that is the relation of ovules to seeds) is very low.

In " C-1," in spite of the full number of seeds, the weight of the *kapas* is the lowest, and if it is proved that this strain has the smallest bolls, it will prove that a small seed is associated with a small size of boll. The actual figures of measurements of bolls in the three strains taken for observation were as follows :—

| Strain | Greatest width of cells of boll | | | Greatest diameter of bolls |
|---|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 | 1921–22 |
| | mm. | mm. | mm. | mm. |
| C-1 .. .. .. | 20 | 20 | 20 | 24 |
| Selection 2 .. .. .. | 22 | 22 | 22 | 26 |
| 1–A Cylindrical Boll .. .. | 22 | 21 | 21 | 25 |

It would appear, therefore, judging by the strains studied that in *broach deshi* cotton increase in size of the bolls does usually indicate an increase in the size of the seeds, and not an increase in their number.

### (*c*) Correlation between the weight of the cotton seed and the weight of the lint on the seed.

It is well known that this correlation does not exist universally among types of cotton, and there are numerous species and varieties of cotton where the seeds are large and the amount of lint small, and *vice versâ*. But within a strain this may happen and if so will be a very important point in judging the variations in the produce in different periods of a season or of several seasons. Balls, working with Egyptian cotton, Harland with Sea Island cotton, and Hilson with Cambodia cotton, have all claimed a positive correlation in these characters.

The results which the author has obtained show that a distinct positive correlation exists in the strains of *broach deshi* cotton. The following correlation tables for two of the strains illustrate the relationship.

(*i*) *Strain* " 1-*A Cylindrical Boll* " (103 *plants examined*).

| Weight of seed in mg. | Frequency of weight of lint per seed | | | |
|---|---|---|---|---|
| | 31 to 35 mg. | 35 to 39 mg. | 39 to 43 mg. | 43 to 47 mg. |
| | plants | plants | plants | plants |
| 53 to 57 .. .. .. .. | 9 | 13 | 1 | 1 |
| 57 to 61 .. .. .. .. | 7 | 26 | 11 | 1 |
| 61 to 65 .. .. .. .. | 2 | 12 | 13 | 3 |
| 65 to 69 .. .. .. .. | .. | 1 | .. | 3 |
| Total .. | 18 | 52 | 25 | 8 |

(*ii*) *Strain* " 1027-*A.L.F.*" 80 *plants examined.*

| Weight of seed in mg. | Frequency of weight of lint per seed | | | | |
|---|---|---|---|---|---|
| | 30 to 34 mg. | 34 to 38 mg. | 38 to 42 mg. | 42 to 46 mg. | 46 to 50 mg. |
| | plants | plants | plants | plants | plants |
| 58 to 62 .. .. .. .. | 1 | 1 | .. | .. | .. |
| 62 to 66 .. .. .. .. | 1 | 1 | .. | .. | .. |
| 66 to 70 .. .. .. .. | 1 | 7 | 3 | .. | .. |
| 70 to 74 .. .. .. .. | .. | 1 | 10 | .. | .. |
| 74 to 78 .. .. .. .. | .. | 2 | 18 | 12 | .. |
| 78 to 82 .. .. .. .. | .. | .. | 16 | 5 | 0 |
| 82 to 86 .. .. .. .. | .. | .. | .. | .. | 1 |
| Total .. | 3 | 12 | 47 | 17 | 1 |

From these figures the following relationships will be seen to exist.

| | 1-A Cylindrical Boll | 1027-A. L. F. |
|---|---|---|
| | mg. | mg. |
| Mean seed weight .. .. .. | 59·5 | 74·7 |
| Mean lint weight per seed .. .. | 37·9 | 40·0 |
| Correlation co-efficient .. .. | + 0·46 | + 0·56 |
| Probable error of correlation co-efficient .. | ± 0·05 | ± 0·05 |

The correlation is significant but not very close, and seems much less than that claimed by the workers named above. But in the present variety

of cotton, even between the produce of different bolls on the same plant, the correlation seems very variable and does not always appear to be very high. The figures for six of the strains studied are as follows. The variation frequency is given in Appendix III.

| Strain | Mean seed weight | Mean lint weight per seed | Correlation co-efficient | Probable error |
|---|---|---|---|---|
| B-1 .. .. .. | 56·9 | 30·4 | + 0·40 | ± 0·08 |
| C-1 .. .. .. | 52·0 | 27·9 | + 0·59 | ± 0·06 |
| 1–A Cylindrical Boll .. .. | 65·5 | 40·5 | + 0·47 | ± 0·08 |
| Selection 2 .. .. .. | 62·6 | 44·6 | + 0·80 | ± 0·04 |
| 1027-A. L. F. .. .. | 62·7 | 38·9 | + 0·58 | ± 0·08 |
| 1–A Long Boll .. .. | 62·8 | 42·9 | + 0·82 | ± 0·04 |

### (*d*) Correlation between the weight of the cotton seed and the length of the staple in heavy seeded strains.

The length of the staple has been taken as that of the lint hairs on the middle of the seed, and for greater security the relationship suggested was determined from the produce of single plants. The frequency of variation is given in Appendix IV.

The following figures may be interesting in this connection as showing the co-efficient of variability of the seed weight and the lint weight and lint length from boll to boll *on a single plant.*

| Strain | Co-efficient of variability | | |
|---|---|---|---|
| | Seed weight | Lint weight | Lint length |
| B-1 .. .. .. | 7·2 | 9·6 | 5·0 |
| C-1 .. .. .. | 11·7 | 14·0 | 4·4 |
| 1027-A. L. F. .. .. | 9·9 | 12·5 | 4·5 |
| 1–A Cylindrical Boll .. .. | 10·1 | 10·1 | 5·3 |
| 1–A Long Boll .. .. | 12·9 | 17·0 | 8·2 |
| Selection 2 .. .. .. | 10·8 | 11·2 | 8·2 |

On the whole, therefore, the lint length was considerably less variable than that of the seed weight and lint weight per seed.

The results were as follows :—

| Strain | Mean length of staple | Correlation co-efficient | Probable error of correlation co-efficient |
|---|---|---|---|
| | cm. | | |
| 1027-A. L. F. .. .. | 2·9 | + 0·70 | ± 0·052 |
| 1–A Cylindrical Boll .. .. | 2·6 | + 0·46 | ± 0·082 |
| Selection 2 .. .. .. | 2·4 | + 0·61 | ± 0·073 |
| 1–A Long Boll .. .. | 2·5 | + 0·68 | ± 0·071 |
| B-1 .. .. .. | 2·3 | + 0·25 | ± 0·089 |
| C-1 .. .. .. | 2·4 | + 0·29 | ± 0·089 |

In the light seeded strains (" B-1 " and " C-1 ") the correlation is small and is certainly not significant. In the others it is more marked, but except perhaps in strain " 1027-A.L.F." it is certainly not close.

## IV. DESCRIPTION OF CERTAIN PURE LINE STRAINS OF *BROACH DESHI* COTTON.

The characters which differentiate the *broach deshi* variety of *Gossypium herbaceum* from the *goghari* variety of the same species have been described in the author's previous Memoir.[1] But in the types which have the characteristics of *broach deshi*, there are many strains which differ from one another by characters which are of direct or indirect economic importance, and which breed true. These strains are, however, not merely mixed. They have crossed with one another to an enormous extent and few, if any, of a pure character now exist in cultivation. Any attempt to make a permanent improvement in the character of the cotton grown, or even to fix a type which shall approach as near as may be to the ideal for the South Gujarat cotton area must be commenced evidently by the isolation of such pure strains, breeding true, which can be used as the basis for establishing types, or of making crosses with other varieties of cotton.

[1] *Mem. Agri. Dept. India, Bot. Ser.*, XI, No. 4, p. 84

Fig. 1. Broach Deshi Strain "B-1"
(Leaves dark green and smaller and broader than those of "C-1")

Fig. 2. Broach Deshi strain "C-1."
(Leaves light green in colour and deeply sected as to have a constriction at the base of the lobe)

COMPARISON OF THE HABIT OF RIPENING OF BROACH DESHI STRAINS.
"B-1" (RIGHT) AND "C 1" (LEFT).

PLATE III.

It is now proposed to describe six such pure strains, which have been isolated, in order to indicate the range of variation which exists in *broach deshi* cotton, and also the fluctuation of characters within the strain itself. The strains described have been in pure line culture since 1918-19 or 1919-20.

## Strain " B-1."

The first of these strains which has been termed " B-1 " is derived from a selection originally made in 1916-17 on the basis of the size and shape of the boll. In the case of the parent of the present strain the boll was round but slightly pointed at the top. The progeny of the original plant varied much in 1917-18, and it was obvious that a good deal of splitting had occurred. From 1918-19, the plants secured from self-fertilized parents were uniform, and from 1919-20 the strain has been maintained from protected flowers. It has bred absolutely true since then with the following characteristics :—

(1) The plants of this strain are of a bushy character, and bear a number of monopodia varying from none to ten. The most frequent number of monopodia in all the years from 1919-20 to 1921-22 has been six. The leaves of this strain are characterized by a specially dark green colour, and by being smaller and broader than in other strains. This character of the leaf can be distinguished when the plants have grown for nearly two months and is shown in Plate II. Fig. 1.

(2) The most frequent node from which the first primary fruiting branch arises was the 19th (counting from the base) in 1919-20, the 12th or 13th in 1920-21, and the 18th or 19th in 1921-22.

(3) The strain under consideration is the earliest in ripening among all the types examined, and it is for this character that it has been maintained in our collections. The habit can be best shown by the proportion of the total yield given which was harvested in the first picking. This amounted to 71 per cent. in 1918-19, when another strain (" C-1 ") grown beside it only gave 45 per cent. Similarly in 1919-20, 60 per cent. of the yield was produced in the first picking, while the adjoining plants of " C-1 " only gave 36 per cent. In comparison with the same strain in 1920-21, it was a fortnight earlier (Plate III). This characteristic is due to the fact of its producing a large number of fruiting branches from accessory buds both on the main stem and on the monopodia. It is, consequently, not a very leafy variety. It sheds a very large proportion of its flower buds and flowers and is a low yielding strain.

(4) The average measurements of the bolls, in centimeters, were as follows in three separate years :—

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. .. .. | .. | .. | 2·4 |
| Length from gland to tip .. .. | 2·9 | 2·9 | 2·9 |
| Greatest width of one cell .. .. | 2·0 | 2·0 | 2·0 |
| Width of cell 7 mm. from tip .. .. | .. | 1·1 | 1·1 |

(5) The average weight of each seed (average of 2,000 seeds in each case) is as follows :—

| | mg. |
|---|---|
| 1918–19 .. .. .. .. .. | 55·1 |
| 1919–20 .. .. .. .. .. | 54·0 |
| 1920–21 .. .. .. .. .. | 52·1 |
| 1921–22 .. .. .. .. .. | 53·9 |

The seed is, hence, lighter than in most of the other strains studied. In 1921-22, the variability of the seed weight from boll to boll on a single plant was studied, and it was found to be less than in any other strain, the co-efficient of variability being 7·2.

(6) The average weight of lint per 100 seeds (lint index) in four successive years is as follows :—

| | grm. |
|---|---|
| 1918–19 .. .. .. .. .. | 2·9 |
| 1919–20 .. .. .. .. .. | 2·7 |
| 1920–21 .. .. .. .. .. | 2·8 |
| 1921–22 .. .. .. .. .. | 2·9 |

In 1921-22, the variability of the lint index from boll to boll on a single plant was studied, and it was found to be less than in any other strain, the co-efficient of variability being 9·6.

Where the seed weight is varying, the lint index forms a better means of comparison between the proportion of lint to seed in different strains and in different seasons than the ginning percentage. This last figure was as follows, however, in the four years quoted, 1918-19, 34·8 ; 1919-20, 33·1 ; 1920-21, 35·5 ; 1921-22, 34·9.

(7) The length of staple is practically the same as that of the average of *broach deshi* cotton in cultivation. In 1921-22, the actual measurements

at the tip, middle and base were made on 180 seeds, with the following results.

| | Average length of staple |
|---|---|
| | cm. |
| Lint on tip of seed .. .. .. | 1·9 |
| Lint on middle of seed .. .. | 2·4 |
| Lint on base of seed .. .. .. | 2·3 |

The variation from the mean (*a*) at the tip was 15·7 per cent. below, (*b*) at the middle was 10·5 per cent. above, and (*c*) at the base 5·3 per cent. above. The co-efficient of variability from boll to boll on a single plant in 1921-22 was 5·0.

The lint on the middle of the seed varied as follows in 1921-22 as determined from 180 measurements on different seeds.

| | |
|---|---|
| Number of measurements made .. .. | 180 |
| | Per cent. |
| Staple of 1·7 to 1·9 cm. .. .. | 3 |
| „ 1·9 to 2·1 „ .. .. | 7 |
| „ 2·1 to 2·3 „ .. .. | 14 |
| „ 2·3 to 2·5 „ .. .. | 32 |
| „ 2·5 to 2·7 „ .. .. | 37 |
| „ 2·7 to 2·9 „ .. .. | 7 |

The variation is illustrated in Fig. 3 below.

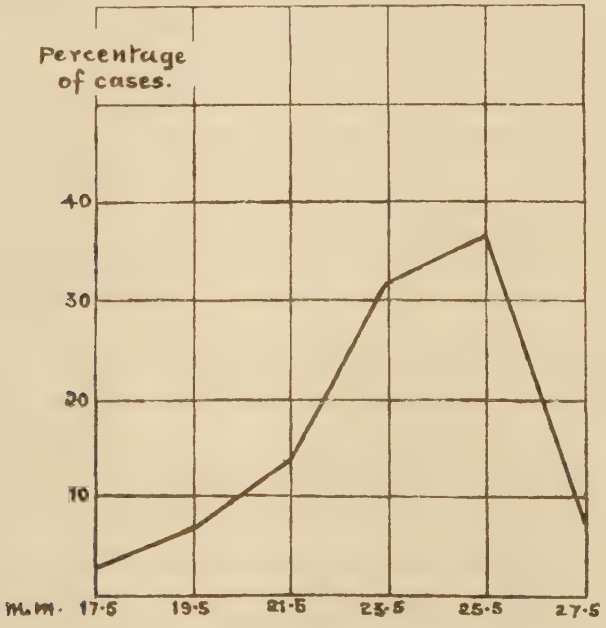



FIG. 3. Variation in staple in strain "B-1" in 1921-22.

The lint from this strain was examined by the Millowners' Association, Bombay, 1921-22, with the following results :—

" Value of lint per candy of 784 lb. is rupees eighty more than *fully good broach.* The lint is strict superfine, with good colour and nice fibre, but not so long."

STRAIN " C-1."

In the same year as the strain previously described, that now under consideration was selected at Surat. In 1918-19 it was found to be quite pure and since then it has bred absolutely true to type. Since 1919 it has been maintained as a pure line. The strain has the following characters.

(1) The plants of this strain are the least bushy of all the selected types of *broach deshi* cotton that have been isolated. The number of monopodia varies from one to nine, but the most frequent number in 1919-20 was 5, in 1920-21 was 5 to 6, and in 1921-22 was 5.

The leaves of the plants of this strain are light green in colour and are longer and more deeply lobed than those of other types. There is also a marked constriction at the base of each lobe. These characteristics are shown in Plate II. Fig. 2.

The first primary fruiting branch arises from a lower node than in any other strain. The most frequent node at which this occurs has been the 17th in 1919-20, the 13th in 1920-21 and the 17th or 18th in 1921-22.

The special feature of this strain is that the internodes on the main stem (from the thirtieth upward) are long and hence the plants have an open habit of growth. This is shown in the following table, where other strains are compared with it as grown in 1921-22.

| | Length of the main stem from 30th to 35th node inches |
|---|---|
| 1–A Cylindrical Boll .. .. .. | 7·3 |
| 1–A Long Boll .. .. .. | 7·2 |
| B-1 .. .. .. .. | 7·0 |
| C-1 .. .. .. .. | 8·4 |
| Selection 2 .. .. .. | 7·6 |

The axillary vegetative branches behave similarly.

As a result the plants are less attacked by bollworm in the early stages. A greater percentage of success in flower buds is attained, therefore, in the early part of the season (see page 201). The percentage of success of bolls from flowers is high.

(3) The bolls of this strain are long, narrow, and tapering. The average measurements of the bolls, in centimeters, were as follows in three separate years :—

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. .. .. | .. | .. | 2·3 |
| Length from gland to tip .. .. | 3·1 | 2·9 | 3·0 |
| Greatest width of one cell .. .. | 2·0 | 2·0 | 2·0 |
| Width of cell 7 mm. from tip .. .. | .. | 1·0 | 1·0 |

This strain produces a large number of four-celled bolls.

(4) The average weight per seed is as follows :—

| | mg. |
|---|---|
| 1918–19 .. .. .. .. | 50·4 |
| 1919–20 .. .. .. .. | 50·5 |
| 1920–21 .. .. .. .. | 53·3 |
| 1921–22 .. .. .. .. | 51·4 |

The seed is hence lighter than in any other of our strains, even lighter than in " B-1." In 1921-22, the variability of the seed weight from boll to boll of a single plant was greater than in the strain previously described, the co-efficient of variability being 11·7.

(5) The average weight of lint per 100 seeds (lint index) in four successive years is as follows :—

| | grm. |
|---|---|
| 1918–19 .. .. .. .. | 2·9 |
| 1919–20 .. .. .. .. | 2·4 |
| 1920–21 .. .. .. .. | 2·8 |
| 1921–22 .. .. .. .. | 2·8 |

In 1921-22, the variability of the lint index from boll to boll on a single plant was found to be higher than in most of the strains. The co-efficient of variability was 14·0.

The ginning percentage may also be quoted for each of the four seasons. It is shown as follows :—

| | Per cent. |
|---|---|
| 1918–19 .. .. .. .. | 36·3 |
| 1919–20 .. .. .. .. | 32·5 |
| 1920–21 .. .. .. .. | 34·5 |
| 1921–22 .. .. .. .. | 35·2 |

(6) The lint gave the following average measurements in different parts of the seeds in 1920-21 and 1921-22.

| | Length of staple | |
|---|---|---|
| | 1920–21 | 1921–22 |
| | cm. | cm. |
| Lint on tip of seed .. .. | 1·7 | 2·0 |
| Lint on middle of seed .. .. | 2·0 | 2·5 |
| Lint on base of seed .. .. | 2·0 | 2·4 |

The variations from the mean, taking the two years together, (*a*) at the tip was 11·7 per cent. below, (*b*) at the middle was 6·9 per cent. above, and (*c*)

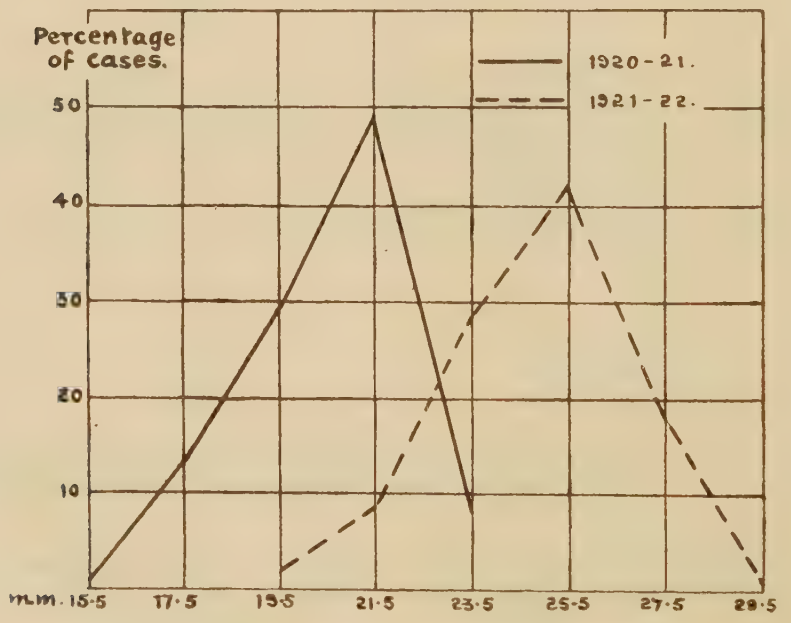



Fig. 4. Variation in staple in strain "C-1" in 1920-21 and 1921-22.

at the base was 4·7 per cent. above. The co-efficient of variability from boll to boll on a single plant in 1921-22 was 4·4.

The lint on the middle of the seed varied as follows, as determined from 100 measurements in 1920-21 and 174 in 1921-22.

| | 1920–21 | 1921–22 |
|---|---|---|
| Number of measurements made .. | 100 | 174 |
| Staple of 1·5 to 1·69 cm. .. .. | 1 | .. |
| „ 1·7 to 1·89 „ .. .. | 13 | .. |
| „ 1·9 to 2·09 „ .. .. | 29 | 2 |
| „ 2·1 to 2·29 „ .. .. | 49 | 9 |
| „ 2·3 to 2·49 „ .. .. | 8 | 28 |
| „ 2·5 to 2·69 „ .. .. | .. | 42 |
| „ 2·7 to 2·89 „ .. .. | .. | 18 |
| „ 2·9 to 3·09 „ .. .. | .. | 1 |

The co-efficient of variability of the lint measurements from seed to seed was, therefore, 7·8 in 1920-21 and 6·9 in 1921-22.

The lint from this strain was examined by the Millowners' Association, Bombay, with the following results :—

| Year | Value of lint per candy of 784 lb. | |
|---|---|---|
| | Fine *broach deshi.* | "C-1" |
| | Rs. | Rs. |
| 1920–21 .. .. .. | 310 | 315 |
| 1921–22 .. .. .. | 570 | 600 |

On the whole, therefore, this strain may be described as a tall growing type with a sparse habit, with average yielding capacity. The flower buds are less attacked by bollworm than in most other strains. It has been maintained in our collections on these accounts.

### "1-A Cylindrical Boll."

This strain was originally selected in 1917-18. It was an attempt to select for a character easily recognizable in the field. This would enable the

roguing of a crop to be easily accomplished. It was found to be pure in 1919-20, and has been propagated since that time from protected flowers. Since 1921-22 it has been grown on a large scale in the Broach District. The progeny from protected flowers breed absolutely true.

(1) The plants of this strain are the bushiest of all the selected types of *broach deshi* cotton that have been isolated. The number of monopodia per plant varies from 4 to 12, but the most frequent number in 1919-20 was 6, in 1920-21 was 7 to 9, and in 1921-22 was 8 to 9. This great development of monopodia leads to a high yield in most of the seasons in Southern Gujarat. The leaves of this strain are more hairy and hence are comparatively little attacked by sucking insects such as jassids.

(2) The first primary fruiting branch arises at a higher node than with other selections, and also at a greater height on the main stem. The most frequent node at which this occurs has been the 19th in 1919–20, the 15th in 1920–21, and the 20th in 1921–22.

The internodes on the lower part of the main stem (up to the sixteenth node) are longer in this strain than in any of the others. In most seasons the amount of flower-bud shedding is less than with other strains, unless there be rain at the time of flowering, when it is more affected than the type last described. The stigma of the flower in this type is more exserted than in any other type. The number of anthers is smaller.

(3) The bolls of this strain are cylindrical, that is to say, they taper only slightly. The average measurements of the bolls, in centimeters, were as follows in three separate years.

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. | .. | .. | 2·5 |
| Length from gland to tip .. | 3·2 | 3·2 | 3·1 |
| Greatest width of one cell .. | 2·2 | 2·1 | 2·1 |
| Width of cell, 7 mm. from tip . | .. | 1·0 | 1·0 |

This strain produces the least number of four-celled bolls among all the selections.

(4) The average weight per seed is as follows :—

| | mg. |
|---|---|
| 1919–20 .. .. .. .. | 59·1 |
| 1920–21 .. .. .. .. | 56·3 |
| 1921–22 .. .. .. .. | 63·7 |

The seed is, hence, heavier than in the two strains previously described.

The co-efficient of variability of the seed weight from boll to boll of a single plant in 1921–22 was 10·3. The variability of the average seed weight from plant to plant in 1919-20 is less than the above, the co-efficient of variability being 5·4.

(5) The average weight of the lint per 100 seeds (lint index) in three successive years is as follows :—

| | grm. |
|---|---|
| 1919–20 .. .. .. .. | 3·6 |
| 1920–21 .. .. .. .. | 3·6 |
| 1921–22 .. .. .. .. | 3·8 |

This character is more constant from season to season than in any other of the selected strains.

In 1921–22, the variability of the lint index from boll to boll on a single plant was determined and the co-efficient of variability was found to be 10·1. The variability of the average lint index from plant to plant in 1919–20 is less than the above, the co-efficient of variability being 8·6.

The ginning percentage may also be quoted for each of the last three seasons.

| | Per cent. |
|---|---|
| 1919–20 .. .. .. .. | 36·1 |
| 1920–21 .. .. .. .. | 39·4 |
| 1921–22 .. .. .. .. | 37·7 |

When the strain is transferred from Surat to Broach, that is to say to a somewhat earlier and drier climate, the seed weight tends to increase more than the lint weight and hence the ginning percentage tends to decrease.

(6) The lint gave the following average measurements in different parts of the seeds in 1919-20, 1920-21, and 1921-22.

| | Length of staple | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| | cm. | cm. | cm. |
| Lint on tip of seed .. | 2·2 | 1·7 | 2·1 |
| Lint on middle of seed .. | 2·5 | 2·2 | 2·6 |
| Lint on base of seed .. | 2·4 | 2·1 | 2·6 |

The variation from the mean, taking the years together, (*a*) at the tip was 12·6 per cent. below, (*b*) at the middle was 7·9 per cent. above, and (*c*)

at the base was 5·2 per cent. above. The co-efficient of variability from boll to boll on a single plant in 1921–22 was 5·3.

The lint on the middle of the seed varied as follows, as determined from 100 measurements in each case.

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| Number of measurements .. | 100 | 100 | 100 |
| Staple of 1·6 to 1·79 cm. .. | .. | 1 | .. |
| „ 1·8 to 1·99 „ .. | 1 | 13 | .. |
| „ 2·0 to 2·19 „ .. | 4 | 28 | 1 |
| „ 2·2 to 2·39 „ .. | 16 | 28 | 6 |
| „ 2·4 to 2·59 „ .. | 39 | 27 | 22 |
| „ 2·6 to 2·79 „ .. | 27 | 3 | 46 |
| „ 2·8 to 2·99 „ .. | 12 | .. | 20 |
| „ 3·0 to 3·19 „ .. | 1 | .. | 5 |

The co-efficient of variability of the lint measurements from seed to seed was, therefore, 8·8 in 1919–20, 10·0 in 1920–21 and 7·2 in 1921–22.

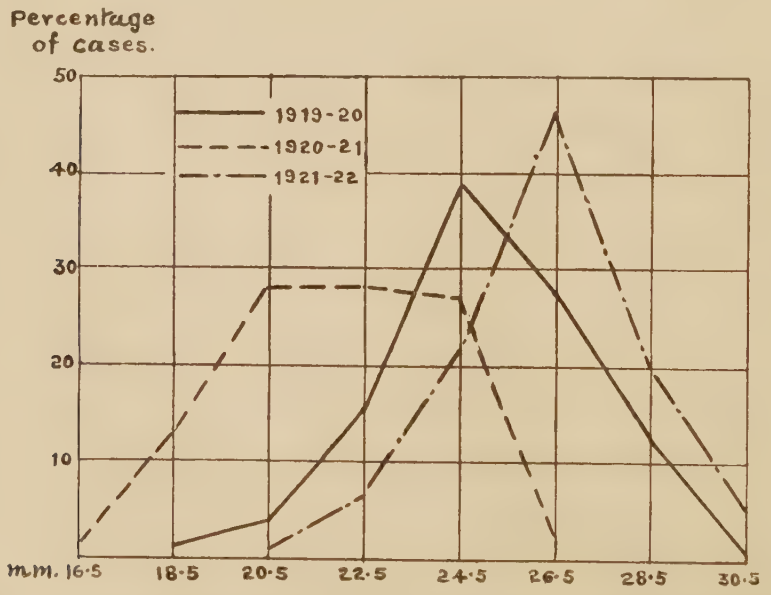



Fig. 5. Variation in staple in strain "I-A Cylindrical Boll" in 1919-20, 1920-21 and 1921-22.

The lint from this strain was examined by the Millowners' Association, Bombay, with the following results :—

| Year | Value of lint per candy of 784 lb. | |
|---|---|---|
| | Fine *broach deshi* | "1-A Cylindrical Boll" |
| | Rs. | Rs. |
| 1920–21 .. | 310 | 325 |
| 1921–22 .. | 570 | 640 |

This strain is particularly valuable on account of its high and constant yield, its high ginning percentage, and good staple. In this last quality it stands only second to "1027-A. L. F." a strain selected from the Navsari area.

### "1-A Long Boll."

This strain was originally selected in 1916–17 with the object mentioned for the strain last described.

It was found to be pure in 1919–20 and has been propogated pure since that time from protected flowers. Since 1921–22, it has been grown on a large scale in the Surat District. The progeny from protected flowers breeds absolutely true.

(1) The plants of this strain are of a bushy character and have a number of monopodia varying from five to eleven. The most frequent number in 1920–21 was seven and in 1921-22 was seven to eight.

(2) The most frequent node from which the first primary fruiting branch arises was fourteenth in 1920–21 and nineteenth to twentieth in 1921–22.

The internodes of the main stem are shorter than in the strain last described. The flowering habit is late and the number of flowers formed in the later part of the flowering period is large. Due to this reason the produce from bolls is particularly free from disease and is superior in "class." The flowers of this strain open more widely than in any other strain.

(3) The bolls of this strain are longer and narrower at the tip than those of other types. The size is also larger than that of other strains. The

average measurements of the bolls in centimeters were as follows in three separate years :—

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. | .. | .. | 2·7 |
| Length from gland to tip .. | 3·8 | 3·6 | 3·6 |
| Greatest width of one cell .. | 2·4 | 2·2 | 2·2 |
| Width of cell 7 mm. from tip | .. | 0·8 | 0·9 |

This strain produces a large number of four-celled bolls. The bolls of this strain do not open so completely as do most of the *broach deshi* strains examined.

(4) The average weight per seed is as follows :—

| | mg. |
|---|---|
| 1919–20 .. .. .. .. | 59·4 |
| 1920–21 .. .. .. .. | 62·1 |
| 1921–22 .. .. .. .. | 64·3 |

The seed is, hence, heavier than in most of the strains.

The co-efficient of variability of the seed weight from boll to boll of a single plant in 1921–22 was 12·9.

(5) The average weight of lint per 100 seeds (lint index) in three successive years is as follows :—

| | grm. |
|---|---|
| 1919–20 .. .. .. .. | 3·8 |
| 1920–21 .. .. .. .. | 4·0 |
| 1921–22 .. .. .. .. | 4·3 |

In 1921–22, the variability of the lint index, from boll to boll on a single plant, was determined, and the co-efficient of variability was found to be 17·0, that is to say, it is higher than in any of the strains examined in detail.

The ginning percentage may also be quoted for each of the last three seasons.

| | Per cent. |
|---|---|
| 1919–20 .. .. .. .. | 39·2 |
| 1920–21 .. .. .. .. | 39·3 |
| 1921–22 .. .. .. .. | 40·1 |

Thus in the present case, the ginning percentage is more constant than the lint index owing to the proportionate increase of seed weight and lint

weight. It is higher than in any of the strains of *broach deshi* cotton examined.

(6) The lint gave the following average measurements in different parts of the seed in 1919–20, 1920–21 and 1921–22.

| | Length of staple | | |
|---|---|---|---|
| | 1919–20 | 1920–21 | 1921–22 |
| | mm. | mm. | mm. |
| Lint on tip of seed .. | 2·2 | 2·0 | 2·1 |
| Length of middle of seed .. | 2·5 | 2·5 | 2·6 |
| Lint on base of seed .. | 2·3 | 2·4 | 2·6 |

The variation from the mean, taking the years together, (*a*) at the tip was 12·2 per cent. below, (*b*) at the middle was 7·1 per cent. above, and (*c*) at the base 4·0 per cent. above. The co-efficient of variability from boll to boll on a single plant in 1921–22 was 8·2. From year to year it is more constant than in any of the strains examined.

The lint on the middle of the seed varied as follows, as determined from 100 measurements, in each case.

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| Number of measurements .. | 100 | 100 | 100 |
| Staple of 1·7 to 1·89 c.m. .. | .. | .. | 1 |
| „ 1·9 to 2·09 „ .. | 2 | 3 | 0 |
| „ 2·1 to 2·29 „ .. | 15 | 10 | 6 |
| „ 2·3 to 2·49 „ .. | 29 | 25 | 18 |
| „ 2·5 to 2·69 „ .. | 30 | 34 | 34 |
| „ 2·7 to 2·89 „ .. | 21 | 23 | 34 |
| „ 2·9 to 3·09 „ .. | 3 | 4 | 7 |
| „ 3·1 to 3·29 „ .. | .. | 1 | .. |

The co-efficient of variability of the lint measurement from seed to seed was, therefore, 9·1 in 1919–20, 9·3 in 1920–21 and 8·1 in 1921–22. The dry

season of 1920-21 had much less effect on the staple than with most of the other strains.

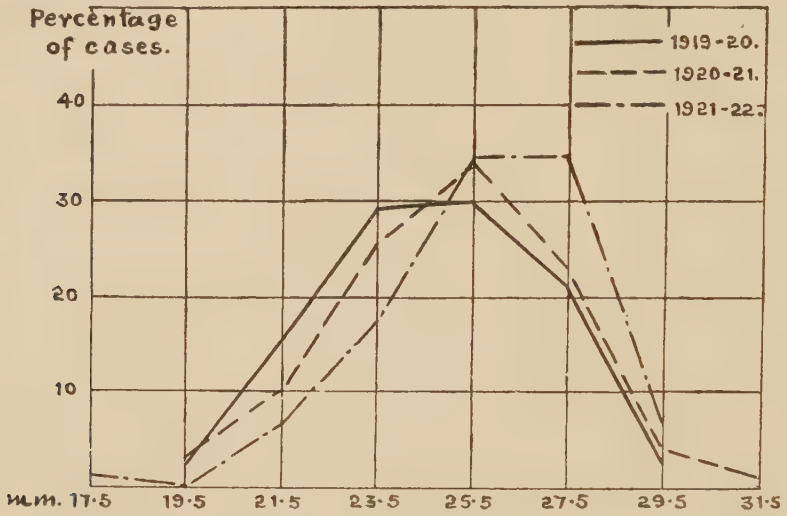



FIG. 6. Variation in staple in strain "I–A Long Boll" in 1919–20, 1920–21 and 1921–22.

The lint from this strain was examined by the Millowners' Association, Bombay, with the following results.

| Year | Value of lint per candy of 784 lb. | |
|---|---|---|
| | Fine *broach deshi* | 1-A Long Boll |
| | Rs. | Rs. |
| 1920–21 .. .. | 310 | 340 |
| 1921–22 .. .. | 570 | 640 |

This strain is particularly valuable on account of its high yield, which is not so seriously affected as other types in dry years, its high ginning percentage and its good staple.

"SELECTION 2."

This strain was originally selected in 1914–15, with the object mentioned for "1-A Cylindrical Boll." It has proved to be pure since 1917–18, and has been propagated since 1919-20 from protected flowers.

(1) The plants of this strain are of a bushy character and have a number of monopodia varying from two to thirteen. The most frequent number in 1920–21 and in 1921–22 was seven.

(2) The most frequent node from which the first primary fruiting branch arises was fifteenth in 1920-21 and nineteenth in 1921-22. Owing to the peculiar spreading habit of the bracts, the flower buds of this strain are less attacked by bollworm than others, but if there be rain at the time of flowering, the strain is much damaged.

This strain has one specially objectionable character. In a year like that of 1920-21, in which the flowering is early, this has the least normal fertility, that is to say, the average number of seeds formed in comparison with ovules is very low. The results are as follows :—

| Strain | 1920–21 | 1921–22 |
|---|---|---|
| | Percentage of seed to ovules | Percentage of seed to ovules |
| Selection 2 .. .. | 75·2 | 91·7 |
| 1–A Long Boll .. | 89·0 | 96·7 |
| 1–A Cylindrical Boll .. | 89·1 | 93·3 |
| 1027–A. L. F. .. .. | 88·0 | 94·5 |
| C–1 .. .. | 95·7 | 94·8 |

(3) The bolls of this strain are cylindrical, that is to say, they taper very slightly. The average measurements of the bolls in centimeters were as follows :—

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. | .. | .. | 2·6 |
| Length of gland to tip .. | 3·2 | 3·1 | 3·1 |
| Greatest width of one cell .. | 2·2 | 2·2 | 2·2 |
| Width 7 mm. from tip .. | .. | 1·0 | 1·0 |

It produces a slightly higher number of four-celled bolls than the strain " 1-A Cylindrical Boll."

(4) The average weight per seed is as follows :—

| | mg. |
|---|---|
| 1917–18 .. .. .. .. | 61·9 |
| 1918–19 .. .. .. .. | 60·9 |
| 1919–20 .. .. .. .. | 60·3 |
| 1920–21 .. .. .. .. | 62·5 |
| 1921–22 .. .. .. .. | 64·2 |

The weight of seed is almost similar to that of " 1-A Long Boll." The co-efficient of variability of the seed weight from boll to boll of a single plant in 1921–22 was 10·8.

(5) The average weight of lint per 100 seeds (lint index) is as follows :—

| | grm. |
|---|---|
| 1917–18 .. .. .. .. | 3·6 |
| 1918–19 .. .. .. .. | 4·0 |
| 1919–20 .. .. .. .. | 3·3 |
| 1920–21 .. .. .. .. | 3·8 |
| 1921–22 .. .. .. .. | 4·4 |

This varies from season to season more than in any of the other strains examined. The co-efficient of variability of the lint index from boll to boll on a single plant in 1921–22 was 11·2.

The ginning percentage may also be quoted as follows :

| | Ginning percentage |
|---|---|
| 1917–18 .. .. .. | 37·1 |
| 1918–19 .. .. .. | 40·0 |
| 1919–20 .. .. .. | 35·4 |
| 1920–21 .. .. .. | 38·1 |
| 1921–22 .. .. .. | 40·7 |

Again in the strain under discussion, the ginning percentage proves to be more constant than the lint index, and this is even more strikingly shown than in the last strain described. It is due to the proportionate increase of seed weight and lint weight.

(6) The lint gave the following average measurements in different parts of the seed in 1920–21 and 1921–22.

| | Length of staple | |
|---|---|---|
| | 1920–21 | 1921–22 |
| Lint on tip of seed .. .. | 2·0 | 2·1 |
| Lint on middle of seed .. .. | 2·4 | 2·5 |
| Lint on base of seed .. .. | 2·3 | 2·4 |

The variations from the mean, taking the years together, (*a*) at the tip was 11·2 per cent. below, (*b*) at the middle was 7 per cent. above, and (*c*) at the base was 3 per cent. above.

The co-efficient of variability from boll to boll on a single plant in 1921–22 was 8·2.

The lint on the middle of the seed varied as follows, as determined from 100 measurements in each case.

| | 1920–21 | 1921–22 |
|---|---|---|
| Staple of 1·7 to 1·8 cm. .. .. | .. | 1 |
| „ 1·9 to 2·0 „ .. .. | 2 | 3 |
| „ 2·1 to 2·2 „ .. .. | 16 | 14 |
| „ 2·3 to 2·4 „ .. .. | 38 | 31 |
| „ 2·5 to 2·6 „ .. .. | 35 | 32 |
| „ 2·7 to 2·8 „ .. .. | 9 | 14 |
| „ 2·9 to 3·0 „ .. .. | .. | 5 |
| „ 3·1 to 3·2 „ .. .. | .. | .. |

The co-efficient of variability of the lint measurements from seed to seed was, therefore, 7·5 in 1920–21 and 9·9 in 1921–22.

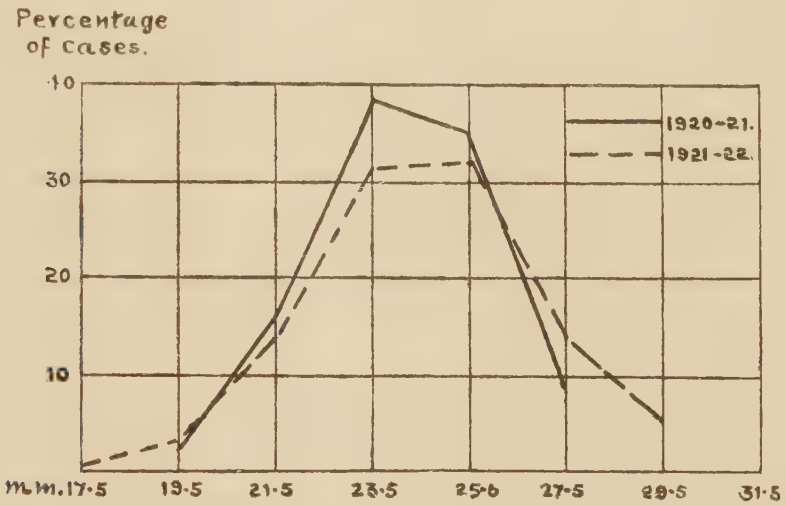



Fig. 7. Variation in staple in strain "Selection 2" in 1920–21 and 1921–22.

The lint from this strain was examined by the Millowners' Association, Bombay, with the following results :—

| Year | Value of lint per candy of 784 lb. | |
|---|---|---|
| | Fine *broach deshi* | Selection 2 |
| | Rs. | Rs. |
| 1920–21 | 310 | 315 |

The strain is maintained amongst our collection on account of the peculiar spreading character of the bracts.

"1027–A. L. F."

This strain was originally selected in 1917-18* from the best type of cotton cultivated in Southern Gujarat. The shape of the boll also enables it to be easily identified in the field. It was found pure in 1919–20 and has been propagated since that time from protected flowers. Since 1921–22 it has been grown on a large scale in the south of the Surat District.

(1) The plants of this strain are of a bushy character and have a number of monopodia varying from 3 to 11. The most frequent number in 1920-21 and 1921–22 was 7 to 8.

(2) The most frequent node from which the first primary fruiting branch arises was fourteen in 1920–21 and nineteen in 1921–22.

The leaves of this strain are particularly dark green and leathery just when the cold weather sets in. This character can be definitely recognized for a month. After this time, in all the strains, the leaves present a similar dark green colour.

The colour of the pollen is of deeper pink than in any other strain.

The vigour of the branches, vegetative as well as fruiting, expressed by growth in nodes is lower than in the other strains described. A large number of abnormalities of leaves and involucres is found in those seasons in which the vegetative growth is great. This results in higher shedding of flower buds in those years.

(3) The bolls of this strain are almost similar to those of "1-A Long Boll," that is to say, they are long and tapering. The average measurements of the bolls in centimeters were as follows in three successive years :—

| | 1919–20 | 1920–21 | 1921–22 |
|---|---|---|---|
| | cm. | cm. | cm. |
| Greatest diameter .. .. | .. | .. | 2·7 |
| Length from gland to tip .. .. | 3·6 | 3·4 | 3·4 |
| Greatest width of one cell .. .. | 2·2 | 2·1 | 2·2 |
| Width of cell 7 mm. from tip .. .. | .. | 1·0 | 1·0 |

The opening of bolls is also similar to that of "1-A Long Boll."

* The name had been previously applied to a mixed type maintained from about ten years earlier.

(4) The average weight per seed is as follows :—

| | mg. |
|---|---|
| 1919–20 .. .. .. .. | 63·2 |
| 1920–21 .. .. .. .. | 65·9 |
| 1921–22 .. .. .. .. | 64·3 |

The seed is heavier than in any of the other strains examined. The co-efficient of variability of the seed weight from boll to boll of a single plant in 1921–22 was 9·9. In the same year the co-efficient of variability of the average seed weight from plant to plant was only 6·7.

The average weight of lint per 100 seeds (lint index) in three successive years was as follows :—

| | grm. |
|---|---|
| 1919–20 .. .. .. .. | 3·0 |
| 1920–21 .. .. .. .. | 3·6 |
| 1921–22 .. .. .. .. | 3·8 |

(5) This character is very varying from season to season, and is also low in comparison with seed weight. In 1921–22, the variability of the lint index from boll to boll on a single plant was determined and the co-efficient of variability was found to be 12·5. The variability of the average lint index from plant to plant in 1921–22 was 7·1.

The ginning percentage may also be quoted for each of the last three seasons :—

| | Per cent. |
|---|---|
| 1919–20 .. .. .. .. | 32·2 |
| 1920–21 .. .. .. .. | 35·3 |
| 1921–22 .. .. .. .. | 35·1 |

Thus it is little higher than is usually found is the mixture of unselected strains commonly grown in the district.

(6) The lint gave the following average measurements in different parts of the seed in 1920-21 and 1921-22.

| | Length of staple | |
|---|---|---|
| | 1920–21 | 1921–22 |
| | cm. | cm. |
| Lint on tip of seed .. .. | 2·0 | 2·4 |
| Lint on middle of seed .. .. | 2·5 | 2·9 |
| Lint on base of seed .. .. | 2·3 | 2·8 |

The variation for the mean, taking the years together, (*a*) at the tip was 12·9 per cent. below, (*b*) at the middle 8·3 per cent. above, and (*c*) at the base 2·5 per cent. above. The co-efficient of variability from boll to boll on a single plant in 1921-22 was 4·5.

The lint on the middle of the seed varied as follows :—

| | 1920–21 | 1921–22 |
|---|---|---|
| Number of measurements .. .. | 100 | 1,324 |
| | per cent. | per cent. |
| Staple of 1·9 to 2·0 cm. .. .. | 4 | .. |
| ,, 2·1 to 2·2 ,, .. .. | 8 | 1 |
| ,, 2·3 to 2·4 ,, .. .. | 32 | 4 |
| ,, 2·5 to 2·6 ,, .. .. | 30 | 17 |
| ,, 2·7 to 2·8 ,, .. .. | 25 | 35 |
| ,, 2·9 to 3·0 ,, .. .. | 1 | 28 |
| ,, 3·1 to 3·2 ,, .. .. | .. | 13 |
| ,, 3·3 to 3·4 ,, .. .. | .. | 2 |

The co-efficient of variability of the lint measurements from seed to seed was therefore 8·7 in 1920-21 and 8·2 in 1921-22.

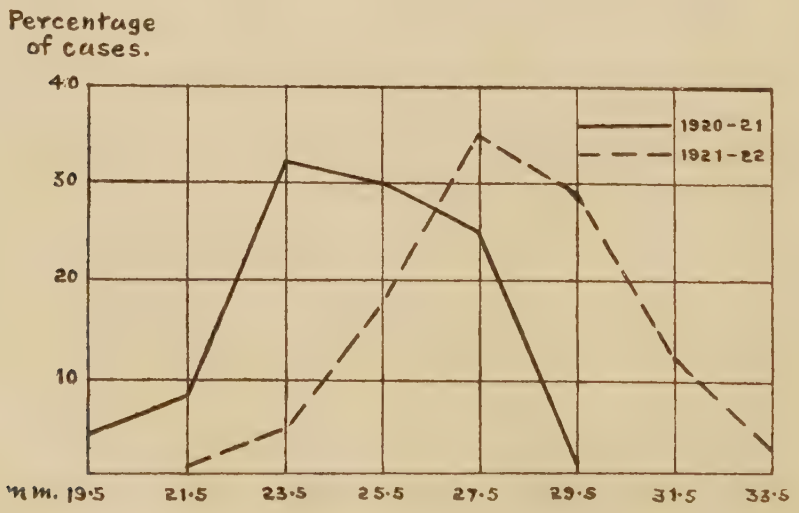



Fig. 8. Variation in staple in strain "1027–A. L. F." in 1920–21 and 1921–22.

The lint from this strain was examined by the Millowners' Association, Bombay, with the following results.

| Year | Value of lint per candy of 784 lb. | |
|---|---|---|
| | Fine *broach deshi* | 1027–A.L.F. |
| | Rs. | Rs. |
| 1920–21 .. .. | 310 | 335 |
| 1921–22 .. .. | 570 | 640 |

This strain is particularly valuable on account of its long silky staple with creamy white colour.

### Comparison of strains of *broach deshi* cotton.

From the description of the six strains, which, out of a very large number of selections made, have been maintained, it will be seen that each has some special quality, cultural or otherwise, which gives it value. We may now summarize the commercial qualities of these types, in respect to the yield per acre, the ginning percentage of the *kapas*, the length of staple of the lint, and the market value of the lint. The results are based on figures obtained from the average of the produce of three years' cultivation in comparable plots.

| Strain | Yield of *kapas* per acre | Yield of lint per acre | Ginning percentage | Value per candy | Value of lint per acre | Average length of staple. Middle of seed |
|---|---|---|---|---|---|---|
| | lb. | lb. | | Rs.** | Rs. | cm. |
| B–1 .. .. | * | .. | 34·5 | 467 | .. | 2·4(a) |
| C–1 .. .. | * | .. | 34·1 | 458 | .. | 2·25† |
| 1-A Long Boll .. | 640 | 248 | 38·2 | 490 | 155·0 | 2·52 |
| 1-A Cylindrical Boll .. | 718‡ | 278‡ | 38·7 | 482 | 170·9‡ | 2·43 |
| Selection 2 .. | 485 | 185 | 38·2 | .. | .. | 2·45† |
| 1027 A. L. F. .. | 586 | 206 | 35·2 | 488 | 128·2 | 2·7† |
| Average of local *broach deshi* .. | 502 | 171 | 34·1 | (Surat–440) (Navsari—458) | 95·9 | 2·2 |

* Figures comparable with the others are not in hand for these strains, as they were grown in different areas. "C–1" in 1920–21 and 1921-22 gave 442 lb. *kapas* per acre in land on which "1-A Long Boll" gave 478 lb. per acre. Similarly in 1919–20 when "C–1" gave 594 lb., "B–1" only 469 lb.

‡ 1919–20 and 1920–21 only, as 1921–22 was a bad year. The true average is below this figure.

† 1920–21 and 1921–22 only.

(a) 1921-22 only.

** Average of 1920–21 and 1921–22. Surat local cotton is taken at Rs. 440 per *candy*.

In the local *broach deshi* cotton at Surat (which is of course a mixture) the proportion of the seeds (average of three years) which had staple of different lengths is as follows :—

| cm. | Per cent. |
|---|---|
| 1·4 to 1·59 .. .. .. .. | 1·0 |
| 1·6 to 1·79 .. .. .. .. | 3·7 |
| 1·8 to 1·99 .. .. .. .. | 8·3 |
| 2·0 to 2·19 .. .. .. .. | 27·7 |
| 2·2 to 2·39 .. .. .. .. | 28·0 |
| 2·4 to 2·59 .. .. .. .. | 20·6 |
| 2·6 to 2·79 .. .. .. .. | 9·7 |
| 2·8 to 2·99 .. .. .. .. | 1·0 |

The variations in the staple of the local cotton are shown for each year in the attached diagram.

Spinning tests of certain of these strains (" 1-A Long Boll," " 1027–A. L. F.") and of the local *surat* cotton, grown at Surat under identical condi-

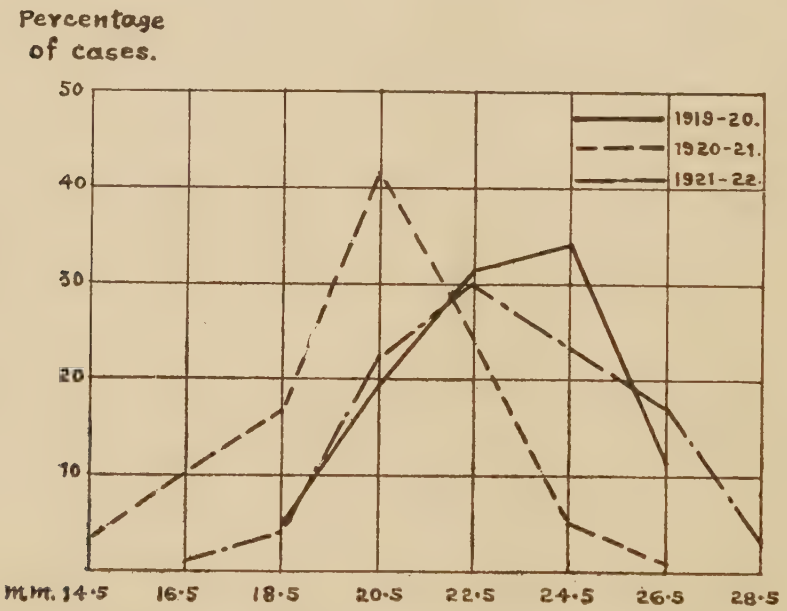



FIG. 9. Variation in staple of local *broach deshi* cotton as grown at Surat in 1919–20, 1920–21 and 1921–22.

tions, have been made for the author by the New Great Eastern Spinning and Weaving Co., Ltd., Bombay, and very sincere acknowledgments of the help given by this company are due. The lint tested was of 1921-22, and the tests were made along with the ordinary yarn drawn in the mills. The

machines, as noted by the company, should have been specially set to the staple of the cotton samples, but as there were no spare machines, this could not be done. Owing to the insufficiency of inter and roving machines, the arrangements given for attenuation in slubbing was high, and thus higher counts could not be worked. The tests were made during the rainy season so that the loss is stated to be exceptionally heavy. The actual results were as under :—

| Type of cotton. | Total loss up to yarn | Count of yarn spun | Test in pounds |
|---|---|---|---|
| Local Surat cotton .. .. | 27 | 20·2 | 60 |
| 1–A Long Boll .. .. | 22 | 20·1 | 66 |
| 1027-A. L. F. .. .. | 28 | 20·1 | 71 |

As a result of these tests the opinion was expressed that the Surat local cotton supplied was fit up to 20's (weft). It was, however, irregular in staple. " 1-A Long Boll " was fit up to 26's (weft). It was somewhat longer in staple than the *surat* local cotton and more uniform. " 1027-A. L. F." was fit for 24's (warp) and 32's (weft). The relative prices per pound of yarn were 14 annas (*surat* local), 16·4 annas (" 1-A Long Boll"), and 18 annas (" 1027-A. L. F.").

The above tests were made on cotton grown under the author's own supervision on the Surat farm. Strain " 1027-A. L. F." has, however, been grown on a large scale in the district, and the produce so grown was tested at the instance of the purchasers, Messrs. Narandas Rajaram & Co., with the following results.

| | Per cent. |
|---|---|
| Blow room loss .. .. .. .. | 5·5 |
| Card room loss .. .. .. .. | 1·8 |

" In 41's this cotton showed a test of 28 lb. with 28 turns per inch, and in 30's we obtained 53 lb. with 23 turns per inch. From the foregoing it is obvious that the cotton is exceptionally good for 30's, but it is not good enough for spinning up to finer counts. We usually require a test of about 42 lb. in 40's."

Generally, it may be stated that the type to which the above description applies (" 1027-A. L. F.") is the best in staple of all our selections, while " 1-A Long Boll " stands next in this respect. Both of these are now being grown in a large scale, and the farmer is rapidly displacing the local mixture of *broach deshi* strains which has hitherto been grown in the Surat District.

## V. THE IDEAL TYPE OF *HERBACEUM* COTTON IN LOWER GUJARAT.

In the author's former Memoir he attempted to set out the characters which he considered as of primary importance in a type of cotton for the special conditions of Lower Gujarat. Apart from the necessity of as high a ginning percentage and as long a staple as the conditions allow, the following characters of the cotton plants were stated as of great importance in order to secure a high yield in the Lower Gujarat climate.

(1) The plants must be able to resist heavy rain when very young, that is to say, when they have less than six leaves.

(2) The plants must possess a large number of monopodia, *i.e.*, the vegetative branches formed in the lower part of the main stem.

(3) There should be the maximum development of vegetative branches on the plant.

(4) Flowering should not commence till 15th November and should be completed before the end of January.

(5) The bolls should be large and should open completely.

The importance of these points has been confirmed by the work done since the Memoir referred to was issued, but further points must now be emphasized and additional evidence with regard to those mentioned has now been collected.

### (1) A STRAIN WITH LONG INTERNODES ON THE STEM IS TO BE PREFERRED.

The very great importance of the power to resist heavy rain and water logging when young has been already insisted upon. A very great factor in such resistance seems to be the rapidity with which the plants grow in height so that they may not be actually covered with water or soil when very young. In ordinary fields where the soil level varies slightly, the stem and leaves up to a height of nearly six inches are liable to get so covered in years of continuous falls of rain. At such a time, a plant with long internodes has a distinct advantage and hence a strain of this type is to be preferred.

### (2) A STRAIN WITH HAIRY LEAVES IS TO BE PREFERRED.

In many parts of the world it has been considered that hairiness of the leaves is an advantage. This is probably because they are less attacked by sucking insects such as jassids, and it is certain that such plants are healthier and more vigorous than others in South Gujarat. The strain "1-A Cylindrical

Boll," is the hairiest of all the types studied, and this has the most constant yield of all of them.

### (3) A STRAIN WITH HIGH DEVELOPMENT OF VEGETATIVE BRANCHES IS TO BE PREFERRED.

This is a point which has, so far as Southern Gujarat is concerned, been previously insisted upon, but further evidence on the matter has now been collected. Among the *broach deshi* strains studied, the type which yields highest (" 1-A Cylindrical Boll ") is also that which has the greatest number of monopodia (limbs), while that on which the crop is lowest (" C-1 ") has the smallest number of limbs. Again the type " B-1 " in which the ratio of flower buds to vegetative growth is highest, owing to the habit of giving out fruiting branches from accessory buds instead of vegetative branches, gives almost the lowest yield of all (see table on page 245).

Again if the whole vegetative growth of different types is measured (in nodes), it will be found that the strains in which this is greatest will tend to give the highest yields. Under the conditions of Lower Gujarat, this usually means (unlike what is the case in other regions, notably at Dharwar) that the number of flower buds is greater as the following figures for two of our strains show.

| Year | 1-A Cylindrical Boll | | 1027-A. L. F. | |
|---|---|---|---|---|
| | Vegetative growth in nodes | Flower buds | Vegetative growth in nodes | Flower buds |
| 1919–20 .. | 4,318 | 6,464 | 3,430 | 4,736 |
| 1921–22 .. | 2,594 | 2,343 | 2,276 | 1,998 |

This is very important because owing to the necessity of concentrating the flowering into a short period (see below) it is very advantageous to have a very large number of fruiting branches late in the season, each with few nodes, rather than fewer but larger fruiting branches. This is secured by increasing the vegetative growth, as the number of fruiting branches is largely proportional to the amount of such vegetative growth measured in nodes.

### (4) A STRAIN IN WHICH THE PLANT HAS A TALL OPEN HABIT OF GROWTH AND IN WHICH THE BRACTS HAVE A SPREADING HABIT IS TO BE PREFERRED.

One of the very striking features of the flowering of cotton in the *broach deshi* area is its very great intensity during the time when it is going on, and the very short period out of the intense flowering portion of the season during which any large proportion of the flowers successfully produce bolls. This is very remarkable when compared with other countries. In Egyptian cotton, according to Balls, the actual flowering period has been shown to be from 15th June to 24th September, or for three and a quarter months. The full flowering period is of nine weeks. The rate of new flowers per plant rarely exceeds one per day. In Sea Island cotton, flowering starts in the ninth week of the plants' growth and lasts for eighteen to twenty-two weeks more. It comes in full flowering from the fifteenth or sixteenth week and declines from the twenty-second week. That is to say, the full flowering period is for seven weeks. In working with Pima cotton in the Salt River Valley in America King[1] has observed flowers appearing on plants which had commenced flowering 150 days previously. However, he says, the normal period of flowering is from 90 to 110 days, out of which nearly 53 per cent. of the flowers appear within the first 45 days and the number of new flowers rarely exceeds 1·5 per day.

The results of Ewing in Mississippi and Lloyd in Alabama for Upland varieties may also be compared. They have found that the length of the flowering period is from forty to eighty days. From the results of Lloyd it appears that in Upland cotton the flowering is concentrated almost like that in the *broach deshi*, that is to say, two-thirds of the flowers appear within one month. But the most important difference between the Upland varieties in America and the types of *herbaceum* here is that in the former it starts after six to seven weeks' growth of the plant and during this intense flowering period the proportion of flowers producing ripe bolls is nearly 50 per cent., while here it starts from the twelfth to the sixteenth week and the success is only 33 per cent. The long fruiting period of American cotton has been recognized by Bennett (*l. c.*) to be an important factor in enabling poor farming to produce cotton.

The flowering of *broach deshi* cotton at Surat is as follows. In 1918 the flowering period started from the fourteenth week, and the flowering abruptly declined from the seventeenth week. In 1919-20 and 1921-22 it started

[1] *U. S. Dept. Agri. Bull.* No. 1018 (1922), p. 5.

from the seventeenth and sixteenth week respectively, the plants were in full flower from the twenty-fourth week for nearly a month and then the flowering abruptly declined. In 1920-21, flowering commenced from the fifteenth week, the plants were in full flower from the twentieth week for a month, and then the flowering rapidly declined.

The intensity of flowering can be seen by the following figure with three pure strains.

| Strain | Percentage of flowers opening | | |
|---|---|---|---|
| | 1919–20 2nd to 30th Jan.* | 1920–21 6th Dec. to 2nd Jan.† | 1921–22 3rd to 30th Jan * |
| | Per cent. | Per cent. | Per cent. |
| B–1 .. .. | 70·5 | 79·3 | 64·6 |
| 1-A Long Boll .. | 63·0 | 72·5 | 65·8 |
| 1027-A. L. F. .. | 67·4 | 83·5 | 64·7 |

* This was the twenty-fourth to the twenty-seventh week of growth and the eighth to the eleventh week of flowering.

† This was the twentieth to the twenty-third week of growth, and the sixth to the ninth week of flowering.

The intense flowering season lasts, therefore, for nearly a month during which two-thirds or more of the flowers appear. Not only this but out of this intense flowering portion of the season the time during which flowers formed produced a large proportion of bolls is still more limited even to nearly a fortnight.

The following table shows the proportion of flowers which produced ripe bolls during the various parts of the flowering season.

| Weeks of flowering | Proportion of flowers producing ripe bolls | | | | | |
|---|---|---|---|---|---|---|
| | B-1 | | 1-A Long Boll | | 1027-A. L. F. | |
| | 1920–21 | 1921–22 | 1920–21 | 1921–22 | 1920–21 | 1921–22 |
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| 1st three weeks .. | 40 | 21·5 | .. | 15 | .. | 57 |
| 4th week .. | 79 | 38·5 | 63·5 | 16·5 | 72·5 | 50 |
| 5th ,, .. | 65 | 55 | 75 | 32 | 79 | 45 |
| 6th ,, .. | 49·5* | 61·5 | 72* | 56·5 | 69* | 65·5 |
| 7th ,, .. | 14* | 58 | 67* | 64·5 | 36* | 70 |
| 8th ,, .. | 3·5* | 58* | 38·5* | 63* | 18·5* | 58·5* |
| 9th ,, .. | 3* | 54* | 16* | 58* | 8·5* | 45* |
| 10th ,, .. | nil. | 20* | 5 | 28·5* | ·5* | 14* |
| 11th ,, .. | nil. | 2·5* | .. | 4* | .. | 1·5* |

* Represent intense flowering weeks.

It would seem that the intense concentration of flowering into a short period, and the still greater concentration of successful boll formation from flowers into a still shorter period, is one of the principal causes of the relatively low yield in this area. If anything is likely to occur which will damage the flower buds or flowers during this short period (and many such things do occur), a very large percentage of flowers will fall off, and flowers will never develop into bolls. Perhaps the most important of such things is the attack of the bollworm (*Earias* sp.) which is responsible for an enormous amount of loss at each stage. Two features are found to increase resistance to bollworm, namely, (1) a tall open habit of growth in the plant, and (2) a spreading habit of the bracts. The former is found in the strain " C-1 " among the selected strains, and the latter in " Selection 2," both of which suffer less from bollworm attack, and ripen a bigger proportion of flowers to flower buds than the other strains. This is probably because a wasp (*Microbracon lefroyii*), the presence of which has been now found to be common, can more easily attack the worms as they are more exposed in such strains.

### (5) A STRAIN IN WHICH THE NUMBER OF OVULES WHICH DO NOT FORM SEEDS IS LOW IS TO BE PREFERRED.

In no type of cotton do all the ovules form seeds, but the proportion which fails to do so varies very much in different countries, and with different varieties. In *kumpta* cotton, Kottur[1] estimates the loss at five per cent. In the West Indies, Harland[2] finds the loss to be 21·3 per cent. and 32·7 per cent. in three-celled and four-celled bolls respectively, while in American cotton it is variously estimated at from 10 per cent. to 25 per cent.

In *broach deshi* strains tested at Surat, this loss has varied from 3·4 to 24·8 per cent. according to the seasons and strains. The strains differ widely in this matter. " Selection 2 ", for example, seems to be particularly disposed to this kind of wastage, and it shows the highest loss in both 1920-21 and in 1921-22. On the other hand, the loss is much higher in 1920-21 than in 1921-22. Besides this wastage in yield the resulting cotton from such a strain as Selection 2 is undesirable, as it will give a higher percentage of blow room loss in the form of fly.

[1] *Agri. Jour. India*, XVI, pt. I, p. 52.
[2] *West Ind. Bull.* XVII, p. 148.

## TABLES SHOWING CORRELATION BETWEEN LENGTH OF PETIOLE & LEAF BREADTH IN BROACH DESHI COTTON

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### CORRELATION ON THE BASIS OF THE THIRD LEAF FROM THE BASE OF THE MAIN STEM

No OF LEAVES MEASURED, 288

BREADTH OF LEAF IN C.M.

LENGTH OF PETIOLE IN C.M.

| to | 0·9 to 1·0 | 1·1 to 1·2 | 1·3 to 1·4 | 1·5 to 1·6 | 1·7 to 1·8 | 1·9 to 2·0 | 2·1 to 2·2 | 2·3 to 2·4 | 2·5 to 2·6 | 2·7 to 2·8 | 2·9 to 3·0 | 3·1 to 3·2 | 3·3 to 3·4 | 3·5 to 3·6 | 3·7 to 3·8 | 3·9 to 4·0 | 4·1 to 4·2 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 0·5 | 1 | | 2 | | | | | | | | | | | | | | | 8 |
| 0·6 to 0·89 | | | | 1 | | 1 | | | | | | | | | | | | 2 |
| 0·9 to 1·09 | | 1 | | 3 | | 2 | | | 1 | 2 | | | | | | | | 9 |
| 1·1 to 1·29 | | | | | 1 | 3 | 2 | 2 | 4 | | 3 | 1 | | | | | | 16 |
| 1·3 to 1·49 | | | | | 1 | 5 | 5 | 4 | 9 | 6 | 8 | 6 | 3 | 1 | | | | 48 |
| 1·5 to 1·69 | | | | | | 1 | 1 | 7 | 12 | 17 | 19 | 11 | 4 | 1 | 1 | | | 74 |
| 1·7 to 1·89 | | | | | | | | 1 | 6 | 9 | 10 | 17 | 5 | 6 | 3 | | | 57 |
| 1·9 to 2·09 | | | | | | | | | 3 | 3 | 6 | 3 | 3 | 8 | 3 | 3 | | 50 |
| 2·1 to 2·29 | | | | | | | | | | | 2 | 1 | 4 | 8 | 2 | | | 17 |
| 2·3 to 2·49 | | | | | | | | | | 1 | | | | 5 | 1 | | | 7 |
| 2·5 to 2·69 | | | | | | | | | | | | | | 1 | 1 | | 1 | 3 |
| 2·9 to 3·0 | | | | | | | | | | | | | | 1 | 1 | | | 2 |
| TOTAL | 1 | 1 | 2 | 4 | 2 | 12 | 8 | 14 | 35 | 44 | 48 | 45 | 25 | 51 | 13 | 3 | 1 | 288 |

### CORRELATION ON THE BASIS OF THE FOURTH LEAF FROM THE BASE OF THE MAIN STEM

No OF LEAVES MEASURED, 314

BREADTH OF LEAF IN C.M.

LENGTH OF PETIOLE IN C.M.

| to | 1·3 to 1·4 | 1·5 to 1·6 | 1·7 to 1·8 | 1·9 to 2·0 | 2·1 to 2·2 | 2·3 to 2·4 | 2·5 to 2·6 | 2·7 to 2·8 | 2·9 to 3·0 | 3·1 to 3·2 | 3·3 to 3·4 | 3·5 to 3·6 | 3·7 to 3·8 | 3·9 to 4·0 | 4·1 to 4·2 | 4·3 to 4·4 | 4·5 to 4·6 | 4·7 to 4·9 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 0·5 | 2 | | | 1 | | | | | | | | | | | | | | | 3 |
| 0·6 to 0·8 | 1 | 1 | | 1 | | | | | | | | | | | | | | | 3 |
| 0·9 to 1·0 | | 1 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | | | | | | | | | | 13 |
| 1·1 to 1·2 | | 1 | | 4 | 4 | 4 | 6 | 7 | 8 | 2 | | | | | | | | | 30 |
| 1·3 to 1·4 | | | | 1 | 3 | 7 | 10 | 10 | 8 | 4 | 3 | 1 | | | | | | | 47 |
| 1·5 to 1·6 | | | | 1 | 2 | 7 | 9 | 15 | 15 | 13 | 5 | 10 | 1 | | | | | | 78 |
| 1·7 to 1·8 | | | | | 1 | | 2 | 3 | 15 | 5 | 10 | 4 | 3 | | | | 1 | | 60 |
| 1·9 to 2·0 | | | | | | | | 7 | 7 | 10 | 5 | 9 | 3 | | | | | | 41 |
| 2·1 to 2·2 | | | | | | | | 1 | 3 | 4 | 8 | 7 | 5 | 3 | | | | | 26 |
| 2·3 to 2·4 | | | | | | | | | | | 5 | 1 | 3 | | 2 | | | | 11 |
| 2·5 to 2·6 | | | | | | | | | | | | 1 | 2 | | 1 | 1 | | 2 | 7 |
| 2·7 to 2·8 | | | | | | | | | | | 1 | 1 | | 1 | | | 2 | | 5 |
| TOTAL | 3 | 3 | 3 | 11 | 11 | 20 | 28 | 50 | 51 | 38 | 32 | 34 | 17 | 4 | 3 | 1 | 3 | 2 | 314 |

## CORRELATION ON THE BASIS OF THE FIFTH LEAF FROM THE BASE OF THE MAIN STEM

NO OF LEAVES MEASURED, 296

BREADTH OF LEAF IN C.M.

| LENGTH OF PETIOLE IN C.M. | 1·1 to 1·2 | 1·3 to 1·4 | 1·5 to 1·6 | 1·7 to 1·8 | 1·9 to 2·0 | 2·1 to 2·2 | 2·3 to 2·4 | 2·5 to 2·6 | 2·7 to 2·8 | 2·9 to 3·0 | 3·1 to 3·2 | 3·3 to 3·4 | 3·5 to 3·6 | 3·7 to 3·8 | 3·9 to 4·0 | 4·1 to 4·2 | 4·3 to 4·4 | 4·5 to 4·6 | 4·7 to 4·8 | 4·9 to 5·0 | 5·1 to 5·2 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 0·5 | 1 | | | 1 | | | | | | | | | | | | | | | | | | 2 |
| 0·6 to 0·8 | | 1 | 1 | 3 | 3 | 1 | 2 | 1 | | 1 | | | | | | | | | | | | 13 |
| 0·9 to 1·0 | | | | 2 | 2 | 3 | 4 | 3 | | 1 | 1 | 1 | | | | | | | | | | 17 |
| 1·1 to 1·2 | | | | | | 2 | 3 | 2 | 2 | 3 | 1 | 1 | | | | | | | | | | 14 |
| 1·3 to 1·4 | | | | | 1 | 1 | 5 | 8 | 7 | 6 | 1 | 3 | 2 | | | | | | | | | 34 |
| 1·5 to 1·6 | | | | | 2 | | 3 | 11 | 10 | 12 | 4 | 4 | 1 | | | | | | | | | 47 |
| 1·7 to 1·8 | | | | | | | | 8 | 10 | 11 | 7 | 6 | 7 | 2 | 3 | 1 | | | | | | 55 |
| 1·9 to 2·0 | | | | | | | | 5 | 4 | 9 | 5 | 5 | 11 | 3 | 1 | | 1 | | | | | 44 |
| 2·1 to 2·2 | | | | | 1 | | | | 1 | 1 | 1 | 6 | 3 | 7 | 2 | | 1 | 2 | | | | 25 |
| 2·3 to 2·4 | | | | | | | 1 | | | 3 | 1 | 1 | 5 | 1 | 1 | 3 | | | | 1 | | 17 |
| 2·5 to 2·6 | | | | | | | | | | | 1 | 1 | 2 | 2 | 3 | 4 | | | | | | 13 |
| 2·7 to 2·8 | | | | | | | | | | | 1 | 1 | 1 | | 5 | 1 | | | 1 | | 1 | 11 |
| 2·9 to 3·0 | | | | | | | | | | | | | | | | 1 | | 1 | | | | 2 |
| 3·1 to 3·2 | | | | | | | | | | | | | | | | 1 | | | | | 1 | 2 |
| TOTAL | 1 | 1 | 1 | 6 | 9 | 7 | 18 | 38 | 34 | 47 | 23 | 29 | 32 | 15 | 15 | 11 | 2 | 3 | 1 | 1 | 2 | 296 |

## CORRELATION ON THE BASIS OF THE SIXTH LEAF FROM THE BASE OF THE MAIN STEM

NO OF LEAVES MEASURED, 231

BREADTH OF LEAF IN C.M.

| LENGTH OF PETIOLE IN C.M. | 1·5 to 1·6 | 1·7 to 1·8 | 1·9 to 2·0 | 2·1 to 2·2 | 2·3 to 2·4 | 2·5 to 2·6 | 2·7 to 2·8 | 2·9 to 3·0 | 3·1 to 3·2 | 3·3 to 3·4 | 3·5 to 3·6 | 3·7 to 3·8 | 3·9 to 4·0 | 4·1 to 4·2 | 4·3 to 4·4 | 4·5 to 4·6 | 4·7 to 4·8 | 4·9 to 5·0 | 5·1 to 5·2 | 5·3 to 5·4 | 5·5 to 5·6 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 0·8 | 1 | 2 | 1 | | 1 | 2 | 1 | | | | | | | | | | | | | | | 8 |
| 0·9 to 1·0 | | | 3 | 2 | 4 | 5 | 3 | 1 | | | | | | | | | | | | | | 18 |
| 1·1 to 1·2 | 1 | | | 3 | | 6 | 5 | 3 | 4 | | | | | | | | | | | | | 24 |
| 1·3 to 1·4 | | | 1 | 2 | 2 | 2 | 6 | 9 | 6 | 2 | 2 | 1 | | | | | | | | | | 33 |
| 1·5 to 1·6 | | | | | 1 | 2 | 3 | 10 | 6 | 5 | 8 | 4 | 2 | | | | | | | | | 41 |
| 1·7 to 1·8 | | | | | | 2 | 2 | 2 | 4 | 6 | 4 | 1 | 2 | 1 | | | | | | | | 24 |
| 1·9 to 2·0 | | | | | 1 | 1 | 1 | 1 | | 3 | 7 | 4 | 3 | 2 | | | | | | | | 23 |
| 2·1 to 2·2 | | | | | | | 1 | 1 | 1 | 3 | 1 | 2 | 1 | | 1 | | | | | | | 11 |
| 2·3 to 2·4 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 3 | 3 | | 1 | 1 | | | | | 13 |
| 2·5 to 2·6 | | | | | | | | | 1 | 1 | 1 | 4 | 1 | | 1 | 1 | 1 | | | | | 11 |
| 2·7 to 2·8 | | | | | | | | | 2 | | 1 | | 1 | 1 | 1 | 1 | | | | | | 7 |
| 2·9 to 3·0 | | | | | | | | | | | | 3 | 1 | 2 | 1 | | 1 | | | | 1 | 9 |
| 3·1 to 3·2 | | | | | | | | | | | 1 | 2 | 1 | | 1 | | | | | | | 5 |
| 3·3 to 3·4 | | | | | | | | | | | | | | | | | | | 1 | | | 1 |
| 3·5 to 3·6 | | | | | | | | | | | | | 1 | | | | | 1 | | | | 2 |
| 3·7 to 3·8 | | | | | | | | | | | | | | | 1 | | | | | | | 1 |
| TOTAL | 2 | 2 | 5 | 7 | 9 | 22 | 28 | 28 | 22 | 23 | 24 | 16 | 20 | 10 | 5 | 5 | 4 | 2 | 1 | 1 | 1 | 231 |

## TABLES SHOWING CORRELATION BETWEEN LENGTH OF PETIOLE & LEAF BREADTH IN GOGHARI COTTON

SEE PAGE 219 OF TEXT

### CORRELATION ON THE BASIS OF THE THIRD LEAF FROM THE BASE OF THE MAIN STEM

NO OF LEAVES MEASURED, 141

BREADTH OF LEAF IN C.M.

LENGTH PETIOLE IN C.M.

| to | 2·3 2·4 | 2·7 2·8 | 2·9 3·0 | 3·1 3·2 | 3·3 3·4 | 3·5 3·6 | 3·7 3·8 | 3·9 4·0 | 4·1 4·2 | 4·3 4·4 | 4·5 4·6 | 4·7 4·8 | 4·9 5·0 | 5·1 5·2 | 5·3 5·4 | 5·5 5·6 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 1·4 | 1 | | | | | | | | | | | | | | | | 1 |
| 1·5 1·6 | 1 | 1 | | | | | 1 | | | | | | | | | | 3 |
| 1·7 1·8 | | | | | 1 | 5 | 1 | 1 | | | | | | | | | 8 |
| 1·9 2·0 | | | 2 | 1 | 3 | 1 | 3 | 3 | 2 | | | | | | | | 15 |
| 2·1 2·2 | | | | 2 | 1 | | 7 | 2 | 6 | 3 | | | | | | | 21 |
| 2·3 2·4 | | | | | 1 | 1 | 4 | 6 | 6 | 6 | 1 | 1 | | | | | 26 |
| 2·5 2·6 | | | | | 1 | | 1 | 4 | 5 | 6 | 3 | 2 | 1 | | | | 23 |
| 2·7 2·8 | | | | | | | 1 | | 4 | 2 | 7 | 1 | | | | | 15 |
| 2·9 3·0 | | | | | | 1 | 1 | | 3 | 4 | | 3 | 4 | 1 | | | 17 |
| 3·1 3·2 | | | | | | | | | 1 | 1 | 1 | | | 1 | | 1 | 5 |
| 3·3 3·4 | | | | | | | | | | | | | 2 | 1 | 1 | | 4 |
| 3·5 3·6 | | | | | | | | | | | | 1 | | | | | 1 |
| 3·7 3·8 | | | | | | | | | | | | | 1 | | 1 | | 2 |
| TOTAL | 2 | 1 | 2 | 3 | 7 | 8 | 19 | 16 | 27 | 22 | 12 | 8 | 8 | 3 | 2 | 1 | 141 |

### CORRELATION ON THE BASIS OF THE FOURTH LEAF FROM THE BASE OF THE MAIN STEM

NO OF LEAVES MEASURED, 139

BREADTH OF LEAF IN C.M.

LENGTH OF PETIOLE IN C.M.

| | 2·7 2·8 | 2·9 3·0 | 3·1 3·2 | 3·3 3·4 | 3·5 3·6 | 3·7 3·8 | 3·9 4·0 | 4·1 4·2 | 4·3 4·4 | 4·5 4·6 | 4·7 4·8 | 4·9 5·0 | 5·1 5·2 | 5·3 5·4 | 5·5 5·6 | 5·7 6·0 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 0·8 | | | | | | | | 1 | | | | | | | | | 1 |
| 1·3 1·4 | 1 | | 1 | | 3 | | | | | | | | | | | | 5 |
| 1·5 1·6 | | | | 1 | 2 | 2 | | | | | | | | | | | 5 |
| 1·7 1·8 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | | 2 | | | | | | | | 13 |
| 1·9 2·0 | | | 2 | 4 | 2 | 4 | 2 | 3 | | | | | | | | | 17 |
| 2·1 2·2 | | | | 2 | 6 | 1 | 2 | 2 | 5 | 2 | | | | | | | 20 |
| 2·3 2·4 | | 1 | | | | 2 | 3 | 6 | 3 | 4 | | | | | | 1 | 20 |
| 2·5 2·6 | | | | | 1 | | 3 | 3 | 6 | 3 | 2 | 1 | | 1 | | | 20 |
| 2·7 2·8 | | | | | | 1 | 1 | 3 | 5 | 5 | 2 | 3 | | 2 | 1 | | 23 |
| 2·9 3·0 | | | | | | | 1 | | 3 | 1 | 2 | 1 | | | | | 8 |
| 3·1 3·2 | | | | | | | | | 1 | 1 | | 1 | | 1 | | | 4 |
| 3·3 3·4 | | | | | | | | | | | | | | | | 1 | 1 |
| 3·7 3·8 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - | 2 |
| TOTAL | 2 | 2 | 4 | 10 | 15 | 11 | 15 | 18 | 25 | 16 | 6 | 6 | 1 | 5 | 1 | 2 | 139 |

## CORRELATION ON THE BASIS OF THE FIFTH LEAF FROM THE BASE OF THE MAIN STEM

Nº OF LEAVES MEASURED, 116

BREADTH OF LEAF IN C.M.

| LENGTH OF PETIOLE IN C.M. | to | 2·1 2·2 | 2·3 2·6 | 2·7 2·8 | 2·9 3·0 | 3·1 3·2 | 3·3 3·4 | 3·5 3·6 | 3·7 3·8 | 3·9 4·0 | 4·1 4·2 | 4·3 4·4 | 4·5 4·6 | 4·7 4·8 | 4·9 5·0 | 5·1 5·2 | 5·3 5·4 | 5·5 5·6 | 5·7 5·8 | 6·8 6·4 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW 1·0 | | 1 | | | | | | | | | | | | | | | | | | | 1 |
| 1·3 | 1·4 | | | | | | 1 | | 1 | | | | | | | | | | | | 2 |
| 1·5 | 1·6 | | | | 2 | | 2 | | 1 | 1 | | | | | | | | | | | 6 |
| 1·7 | 1·8 | | | | 2 | 1 | 2 | 2 | 4 | 1 | | | | | | | | | | | 12 |
| 1·9 | 2·0 | | | | | 1 | 3 | 2 | 4 | 2 | | 1 | 1 | 1 | | | | | | | 15 |
| 2·1 | 2·2 | | | | | | | 2 | 2 | 3 | 4 | 2 | 1 | 1 | | | | | | | 15 |
| 2·3 | 2·4 | | | | | | 1 | 2 | 2 | 1 | 1 | 6 | 5 | 1 | 1 | 1 | | | | | 21 |
| 2·5 | 2·6 | | | | | | | | | 1 | 4 | 3 | 4 | 4 | 2 | | | | | | 18 |
| 2·7 | 2·8 | | | | | | | | | | 2 | 3 | 2 | 1 | 2 | 2 | 1 | | | | 13 |
| 2·9 | 3·0 | | | | | | | | | | 1 | | 1 | 1 | 2 | 1 | | 1 | | 1 | 8 |
| 3·1 | 3·2 | | | | | | | | | | | | 1 | | 2 | | | | | | 3 |
| 3·3 | 3·4 | | | | | | | | | | | | 1 | | | | | | | | 1 |
| 3·5 | 3·6 | | | | | | | | | | | | 1 | | | | | | | | 1 |
| TOTAL | | 1 | | | 4 | 2 | 9 | 8 | 14 | 9 | 12 | 15 | 17 | 9 | 9 | 4 | 1 | 1 | | 1 | 116 |

## TABLES SHOWING CORRELATION BETWEEN WEIGHT OF EACH SEED & OF THE LINT FROM EACH SEED ON A SINGLE PLANT

SEE PAGE 223 OF TEXT

### CORRELATION IN STRAIN "B-1"

NO OF BOLLS ON PLANT, 50

WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 67 | | | | | | | | 1 | 1 |
| 65 | | | | | | | 2 | | 2 |
| 63 | | | | | 3 | | 1 | | 4 |
| 61 | | | | 1 | 1 | 2 | 1 | | 5 |
| 59 | | | 1 | 2 | 1 | 2 | 1 | | 7 |
| 57 | | | 1 | 4 | 3 | 1 | | | 9 |
| 55 | | 1 | 1 | 2 | 1 | 2 | | | 7 |
| 53 | | 2 | | 5 | 3 | 1 | | | 11 |
| 51 | | | 1 | | 1 | | | | 2 |
| 49 | 1 | | | 1 | | | | | 2 |
| TOTAL | 1 | 3 | 4 | 15 | 13 | 8 | 5 | 1 | 50 |

### CORRELATION IN STRAIN "C-1"

NO OF BOLLS ON PLANT, 47

WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| | 39 | 43 | 45 | 47 | 49 | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | | 1 | | | | | | | | | | | | 1 |
| 19 | 1 | | | | | 1 | | | | | | | | 2 |
| 23 | | 2 | 1 | 1 | 1 | 1 | | | | | | | | 6 |
| 25 | | | 1 | 1 | | | | 1 | 1 | | | | | 4 |
| 27 | | 1 | | 2 | 2 | 1 | | | | | 1 | | | 7 |
| 29 | | | 1 | | 2 | 1 | 1 | 2 | | | 1 | 1 | | 9 |
| 31 | | | | 1 | | 3 | 1 | 3 | 2 | 2 | 2 | | | 14 |
| 33 | | | | | 1 | | | | | 1 | 1 | | | 3 |
| 35 | | | | | | | | | | | | 1 | 1 | 1 |
| TOTAL | 1 | 4 | 3 | 5 | 6 | 7 | 2 | 6 | 3 | 3 | 5 | 1 | 1 | 47 |

### CORRELATION IN STRAIN "A-CYLINDRICAL BOLL"

NO OF BOLLS ON PLANT, 42

WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 73 | 75 | 79 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | | | | | | | | 1 | | | | 1 |
| 33 | | 2 | | | | | | | | | | 2 |
| 35 | | 1 | | | | | | | | | | 1 |
| 37 | | 1 | 1 | 2 | 2 | | | | | | | 6 |
| 39 | 1 | 1 | 2 | 1 | | 2 | 1 | | | | | 8 |
| 41 | | | 2 | | 3 | | 2 | 1 | 1 | 1 | 1 | 11 |
| 43 | | | | | 1 | | 1 | 1 | | 1 | | 4 |
| 45 | | | | | 1 | | | 1 | 2 | | | 4 |
| 47 | | | | | | | | 2 | | 1 | 1 | 4 |
| 49 | | | | | | | | | | | 1 | 1 |
| TOTAL | 1 | 5 | 5 | 3 | 7 | 2 | 4 | 6 | 3 | 3 | 3 | 42 |

## CORRELATION IN STRAIN "1A-LONG BOLL"

NO OF BOLLS ON PLANT, 26

WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| to | BELOW 47 | 47 50 | 50 53 | 53 56 | 56 59 | 59 62 | 62 65 | 65 68 | 68 71 | 71 74 | OVER 74 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELOW-30 | 1 | | | | | | | | | | | 1 |
| 30-32 | | 1 | 1 | | | | | | | | | 2 |
| 32-34 | | | | 1 | | 1 | | | | | | 2 |
| 34-36 | | | | | 1 | | | | | | | 1 |
| 36-38 | | | | | | | | | | | | |
| 38-40 | | | | | 1 | | | | | | | 1 |
| 40-42 | | | | | 1 | | | 1 | | | | 2 |
| 42-44 | | | | | | 1 | | | 1 | | | 2 |
| 44-46 | | | | | 2 | | 1 | 1 | | | | 4 |
| 46-48 | | | | | | 1 | | 1 | 1 | 3 | | 6 |
| 48-50 | | | | | | | 2 | | | | | 2 |
| 50-52 | | | | | | | | | | | 1 | 1 |
| 52-54 | | | | | | | | | | 1 | | 1 |
| 54-56 | | | | | | | | 1 | | | | 1 |
| TOTAL | 1 | 1 | 1 | 1 | 5 | 3 | 3 | 4 | 2 | 4 | 1 | 26 |

## CORRELATION IN STRAIN "SELECTION 2"

NO OF BOLLS ON PLANT, 34

WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 71 | 73 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 1 | | | 1 | | | | | | | | | 2 |
| 35 | 1 | | | | | | | | | | | | 1 |
| 37 | | | 1 | | | | | | | | | | 1 |
| 39 | 1 | 1 | | | | | | | | | | | 2 |
| 41 | | 1 | | 1 | | 1 | | | | | | | 3 |
| 43 | | | | | | 1 | | 1 | | | | | 2 |
| 45 | | | | | 2 | 2 | 1 | 2 | 1 | | | | 8 |
| 47 | | | | 1 | 1 | 1 | 1 | | | 1 | | 2 | 7 |
| 49 | | | | | | | | 1 | | 1 | | 1 | 3 |
| 51 | | | | | | | | | 1 | | 1 | 2 | 4 |
| 53 | | | | | | | | | | 1 | | | 1 |
| TOTAL | 3 | 2 | 1 | 3 | 3 | 5 | 2 | 4 | 2 | 3 | 1 | 5 | 34 |

CORRELATION IN STRAIN "1027 A.L.F."
No OF BOLLS ON PLANT, 44.
WEIGHT OF SEED IN mgm.

WEIGHT OF LINT PER SEED IN mgm.

| | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | | | 1 | | | | | | | | | 1 |
| 49 | | 2 | 1 | | | | | | | | | 3 |
| 53 | | | 1 | 1 | 1 | | 1 | | | | | 4 |
| 55 | | | | 1 | 1 | | | | | | | 2 |
| 57 | | 1 | | 1 | 1 | 1 | 1 | | | | | 5 |
| 59 | | | | | 3 | | 1 | 1 | | | | 5 |
| 61 | | | | | | 2 | 1 | | | | | 3 |
| 63 | | | | | | 1 | 2 | | | | | 3 |
| 65 | 1 | | | | | | 1 | 1 | | | | 3 |
| 67 | | | | | | 1 | 1 | 2 | | 2 | 1 | 7 |
| 69 | 1 | | | | | 1 | | | | | | 2 |
| 73 | | | | | 1 | | | | 2 | | | 3 |
| 75 | | | | | | | | | 1 | | | 1 |
| 77 | | | | | | | | | 1 | | | 1 |
| 83 | | | | | | | | 1 | | | | 1 |
| TOTAL | 2 | 3 | 3 | 3 | 7 | 6 | 8 | 5 | 4 | 2 | 1 | 44 |

## TABLES SHOWING CORRELATION BETWEEN SEED WEIGHT AND LINT LENGTH ON A SINGLE PLANT

SEE PAGE 223 OF TEXT

### CORRELATION IN STRAIN "B-1"

NO OF BOLLS ON PLANT 50

SEED WEIGHT IN mgm.

LINT LENGTH IN C.M.

| | 49 | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 1 | | | | | 1 | | | | | 2 |
| 25 | | | 2 | 2 | | 2 | 1 | 3 | 1 | | 11 |
| 24 | | 2 | 3 | | 6 | 1 | 3 | | | 1 | 16 |
| 23 | | | 2 | 5 | 2 | 3 | | 1 | 1 | | 14 |
| 22 | 1 | | 1 | | 1 | | 1 | | | | 4 |
| 21 | | | 2 | | | | | | | | 2 |
| 20 | | | 1 | | | | | | | | 1 |
| TOTAL | 2 | 2 | 11 | 7 | 9 | 7 | 5 | 4 | 2 | 1 | 50 |

### CORRELATION IN STRAIN "C-1"

NO OF BOLLS ON PLANT 48

SEED WEIGHT IN mgm.

LINT LENGTH IN C.M.

| to = | 38·1 40 | 42·1 44 | 44·1 46 | 46·1 48 | 48·1 50 | 50·1 52 | 52·1 54 | 54·1 56 | 56·1 58 | 58·1 60 | 60·1 62 | 62·1 64 | 64·1 66 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 39 | 43 | 45 | 47 | 49 | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | TOTAL |
| 2·3 | 1 | 1 | 1 | 1 | 1 | | | 1 | | 2 | | | | 8 |
| 2·4 | | 2 | 2 | 1 | 3 | 2 | 1 | | | 1 | 1 | | | 13 |
| 2·5 | | | | 2 | | 6 | | 2 | 1 | | 2 | | 1 | 14 |
| 2·6 | | 1 | | 1 | 1 | | 1 | 2 | 2 | | 2 | 1 | | 11 |
| 2·7 | | | | | 1 | | | 1 | | | | | | 2 |
| TOTAL | 1 | 4 | 3 | 5 | 6 | 8 | 2 | 6 | 3 | 3 | 5 | 1 | 1 | 48 |

### CORRELATION IN STRAIN "1-A-CYLINDRICAL BOLL"

NO OF BOLLS ON PLANT 42

SEED WEIGHT IN mgm.

LINT LENGTH IN C.M.

| to = | 54 56·0 | 56·1 58·0 | 58·1 60·0 | 60·1 62·0 | 62·1 64·0 | 64·1 66·0 | 66·1 68·0 | 68·1 70·0 | 72·1 74·0 | 74·1 76·0 | 78·1 80·0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 73 | 75 | 79 | TOTAL |
| 24 | 1 | 1 | 2 | | | | 1 | 1 | | | | 6 |
| 25 | | | 1 | 2 | | | | 1 | | 1 | | 5 |
| 26 | | 4 | 2 | | 5 | 1 | | 1 | | 1 | 1 | 15 |
| 27 | | | | 1 | 2 | | 2 | 2 | 2 | | 1 | 10 |
| 28 | | | | | | 1 | | 1 | 1 | | | 3 |
| 29 | | | | | | | 1 | | | 1 | 1 | 3 |
| TOTAL | 1 | 5 | 5 | 3 | 7 | 2 | 4 | 6 | 3 | 3 | 3 | 42 |

## CORRELATION IN STRAIN "HA-LONG BOLL"

### Nº OF BOLLS ON PLANT 26

### SEED WEIGHT IN $\frac{1}{100}$ gm.

LINT LENGTH IN C.M.

| to | BELOW 47 | 47 50 | 50 53 | 53 56 | 56 59 | 59 62 | 62 65 | 65 68 | 68 71 | 71 74 | OVER 74 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2·1 | | 1 | | | | | | | | | | 1 |
| 2·2 | | | | | | | | | | | | |
| 2·3 | | | | | | | | | | | | |
| 2·4 | | | | | 3 | 1 | 1 | 1 | | | | 6 |
| 2·5 | 1 | | 1 | 1 | 2 | | 1 | 1 | | | | 7 |
| 2·6 | | | | | | 1 | 2 | 2 | | | 1 | 6 |
| 2·7 | | | | | | | | | | 3 | | 3 |
| 2·8 | | | | | | | | | 2 | | | 2 |
| 2·9 | | | | | | | | | | 1 | | 1 |
| TOTAL | 1 | 1 | 1 | 1 | 5 | 2 | 4 | 4 | 2 | 4 | 1 | 26 |

## CORRELATION IN STRAIN "SELECTION 2"

### Nº OF BOLLS ON PLANT 34

### SEED WEIGHT IN $\frac{1}{100}$ gm.

LINT LENGTH IN C.M.

| | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 71 | 73 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 1 | | | | | | | | | | | | 1 |
| 21 | | | | | 1 | | | | | | | | 1 |
| 22 | | 1 | 1 | | 1 | | 1 | | | | | | 4 |
| 23 | 1 | | | 1 | 1 | 2 | | 1 | | | | 1 | 7 |
| 24 | 1 | 1 | | 1 | | 1 | | 1 | 1 | | 1 | | 7 |
| 25 | | | | 1 | | 1 | | 1 | 1 | | | | 4 |
| 26 | | | | | | | 1 | 1 | | 1 | | 3 | 6 |
| 27 | | | | | | 1 | | | | 1 | | | 2 |
| 28 | | | | | | | | | | | | 1 | 1 |
| 29 | | | | | | | | | | | | | |
| 30 | | | | | | | | | | 1 | | | 1 |
| TOTAL | 3 | 2 | 1 | 3 | 3 | 5 | 2 | 4 | 2 | 3 | 1 | 5 | 34 |

## CORRELATION IN STRAIN "1027-A L F"

### Nº OF BOLLS ON PLANT 44

### SEED WEIGHT IN $\frac{1}{100}$ gm.

LINT LENGTH IN C.M.

| | 45 | 49 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 73 | 75 | 77 | 85 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2·6 | | | | 1 | | | | | | | | | | | | 1 |
| 2·7 | 1 | | 1 | 1 | | 1 | 1 | | | | | 1 | | | | 6 |
| 2·8 | | 2 | 1 | | 4 | 3 | 2 | 2 | | 1 | | | | | | 15 |
| 2·9 | | 1 | 2 | | | 1 | | 1 | | 3 | | 1 | | 1 | | 10 |
| 3·0 | | | | | 1 | | | | 2 | 2 | 2 | 1 | | | | 8 |
| 3·1 | | | | | | | | | 1 | 1 | | | 1 | | | 3 |
| 3·2 | | | | | | | | | | | | | | | 1 | 1 |
| TOTAL | 1 | 3 | 4 | 2 | 5 | 5 | 3 | 3 | 3 | 7 | 2 | 3 | 1 | 1 | 1 | 44 |

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